



March 2, 2011

Mr. Stephen Hoffman  
US Environmental Protection Agency (5304P)  
1200 Pennsylvania Avenue, NW  
Washington, DC 20460

**Re: Ameren Missouri  
Sioux Power Station  
Response to Dewberry & Davis Draft Coal Combustion Waste Impoundments  
Round 7 – Dam Assessment Report**

Dear Mr. Hoffman:

Below are Ameren Missouri's responses to the Dewberry & Davis draft dam safety assessment of the coal combustion waste (CCW) impoundments at the Sioux Power Station. The draft report was received by Ameren Missouri from the U.S. EPA on February 4, 2011. We have also enclosed a copy of our recently completed stability analysis of the Sioux CCW impoundments as requested by your consultant.

Excerpts of the Dewberry & Davis report are presented in bold faced type and our responses are provided in regular type.

**INTRODUCTION, SUMMARY CONCLUSIONS AND RECOMINDATIONS: In Summary the AmerenUE Sioux Fly Ash Dam is FAIR for continued safe and reliable operation, with acceptable performance expected under all required loading conditions, however minor deficiencies may exist that require remedial action or additional studies/investigations. The AmerenUE Sioux Bottom Ash Dam is FAIR for continued safe and reliable operation, with acceptable performance expected under all required loading conditions, however minor deficiencies may exist that require remedial action or additional studies/investigations. Results of a pending Embankment Stability Analysis currently being conducted for both embankments may affect the safety ratings assigned in this report.**

Response: The subsurface investigation and stability analysis for the Sioux Power Station mentioned in the assessment has been completed and a copy of the report is enclosed with this letter. Based on these results, we request the condition rating be reevaluated prior to issuing the final report.

**1.1.5. Conclusions Regarding the Field Observations: A small seep in the northeast corner of the Bottom Ash Pond dam was observed 75' from the toe of the embankment with clear water exiting the area. AmerenUE is monitoring the situation on a weekly basis.**

Response: Ameren Missouri will continue to monitor the seepage for clarity and volume fluctuations during the weekly inspections. Ameren has initiated a project to install an inverted filter along the seepage area and plans to implement this project in 2011.

**1.2.2. Recommendations Regarding the Hydrologic/Hydraulic Safety: It is recommended that AmerenUE conduct an updated hydrologic/hydraulic safety study to reflect current conditions.**

Response: A hydrologic/hydraulic analysis was completed by Reitz & Jens, Inc. August 27, 2007 and a copy of this report was provided to the EPA consultant. According to the Reitz & Jens, Inc. hydrologic/hydraulic study, there is sufficient capacity to store water from the 100 year event if normal pool elevations of 440 feet in the Fly Ash Pond and 440.5 feet in the Bottom Ash Pond are maintained.

**1.2.5. Recommendations Regarding the Field Observations: It is also recommended that removal of the woody vegetation along the bottom ash pond, southeast side, should continue if the filled area is planned to be removed and used as an embankment in the future.**

Response: Ameren is currently using the filled area as a parking/staging lot and has no future plans to remove the filled area.

**1.2.6. Recommendations Regarding the Maintenance and Methods of Operation: Maintain existing embankment slopes to keep vegetation controlled and to allow for easy visual inspection of the dams.**

Response: Ameren will continue a regular maintenance program to control vegetation.

**5.2.3 Downstream/Outside Slope and Toe: Figure 5.2.3-1 shows one of the eroded areas near the northwest corner of the embankment.**

Response: Since the time of the inspection this area has been regraded and repaired utilizing geotextile and riprap for the entire length of this face to minimize future erosion. This project was completed in January, 2011.

**5.3.3 Downstream/Outside Slope and Toe: A small seep was observed (Fig. 5.3.3-2) in the northwestern corner of the pond embankment, approximately 75' from the toe of the embankment.**

Response: See 1.1.5 Above.

**5.4.3 Emergency Spillway: No emergency spillway is present for either the Fly Ash Pond or Bottom Ash Pond.**

Response: The emergency isolation gate installed in the bottom ash pond water control structure also serves as an emergency spillway for the bottom ash pond. In an emergency situation this gate structure will be overtopped and route flow through the outlet pipe and prevent overtopping on the perimeter embankment.

**Errors and Omissions:**

**Section 2.4.2**

We no longer have any stop logs installed in the bottom ash pond water control structure; it has been replaced with a new emergency gate isolation system for flow control. An emergency isolation gate was added to the bottom ash pond discharge structure. This also applies to 4.2.2 as well.

**Figure 5.3.3-2**

The small seep is in the northeastern portion of the pond not the "northwestern."

**Section 5.4.1**

The corrugated skimmer is incorrectly described as "the outfall structure". A section of the corrugated was removed to allow excess volume to flow from the bottom ash pond. The majority of the inflow comes from the 24" HPDE Pipe that has a suction bell below the water surface. The boom curtain was added to contain oils and debris from being discharged from the bottom ash structure.

Figure 5.4.1-1

This figure should be titled emergency isolation gate system for flow control.

Section 8.2

The section should read; Dam Safety Program for Ameren UE Non-Hydroelectric Facilities vs. Cailities

General:

Ameren UE is now Ameren Missouri

Sections 2.2, 2.4.1, & 5.2.2 The liner that was installed in the fly ash pond is not 60mm (millimeters) thick. It should be 60 mils.

### **Business Confidentiality Claim**

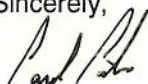
We request the Draft Dam Safety Assessment Report for the Sioux Power Station prepared by Dewberry & Davis, as well as our responses to this report remain confidential. We also request the attached Sioux Ash Pond Dam Stability Analysis Report be kept confidential. This request is made in accordance with the procedures described in 40 CFR, Part 2, Subpart B.

When initially submitting support documents to Dewberry & Davis for preparation of their report we also designated the following materials as confidential:

- Plans of the embankment
- EIP
- Dam Safety Program for AmerenUE Non-Hydro Facilities
- Reitz & Jens, Inc. August 27, 2007 Phase I Report
- Subsurface Investigation, Evaluation and Recommendation with Planning and General Design , Feb. 1981
- Soil Borings and Pile Data dated April 2, 1979
- 2008 and 2009 Inspection Reports
- Weekly Inspection Reports

If you need further information, please feel free to contact me at 314-554-2388.

Sincerely,



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Enclosures



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November 16, 2010

**CONFIDENTIAL**

Mr. Matt Frerking  
Managing Supervisor – Dam Safety  
Ameren Missouri  
3700 South Lindberg, MC F-604  
Sunset Hills, Missouri 63127

RE: Ash Pond Dam Stability Analysis  
Sioux Power Station

Dear Mr. Frerking:

This report presents our findings and recommendations from the geotechnical field investigations, laboratory testing, land survey, and slope stability analyses of the dams impounding the ash ponds at the Sioux Power Station. The investigation, testing and analyses was done in general accordance with our proposal dated January 29, 2010, and Ameren Missouri's request for proposal dated December 9, 2009. The purpose of this project is to evaluate the stability of the ash pond dams and conduct the necessary land surveys, subsurface explorations, and laboratory testing to define the critical section at each location. The slope stability analysis conducted was for the load cases required by the Missouri Department of Natural Resources (MDNR). The results of the slope stability analysis were compared to the required safety factors for the type and assumed hazard classification of each dam.

In 2007, Reitz & Jens (RJ) completed the Phase I: AmerenUE Dam Inventory and Inspection Program project. This project was a preliminary study and consisted of determining the existing condition and classification status of the dams at Rush Island, Meramec, Labadie and Sioux Power Stations and developing a site specific inspection program at each power station. The project involved field inspections, surveys, site reconnaissance, research of current registration requirements, and pertinent computations. Site specific recommendations for future inspections were developed which include inspection templates, frequency of monitoring and maintenance recommendations. The study reported that the height of the Sioux bottom ash pond dam was approximately 27 feet and fly ash pond dam was approximately 22.3 feet, and that the dams did not fall under the current MDNR regulation that requires all dams 35 feet or more in height to be regulated. The report also found no dwellings downstream of the dams and if regulation were necessary the dams would be categorized within Environmental Site Class III. The MDNR dam safety regulations have not changed since the 2007 report.

### SURVEY

A land survey was conducted to determine the elevation profile along the crest of the dam. The extents of the survey were chosen to include the areas with the greatest elevation difference between the crest and the downstream toe and the segments impounding water or unconsolidated sediment. Cross-

Geotechnical Engineering • Water Resources • Construction Engineering & Quality Control • Environmental Restoration & Permitting



AASHTO National Lab Accreditation

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sections were also surveyed at multiple locations at each plant to determine the slope heights and geometry. Zahner and Associates, Inc. conducted the survey, as a subcontractor to RJ. At the Sioux Power Station an elevation survey of the crest over approximately 2,300 lineal feet of the bottom ash pond and 2,100 feet of the fly ash pond was conducted. Elevation profile measurements were taken at 100 foot intervals. The extents of the elevation profile are shown in Figure 1 and a plot of the measured elevations is presented in Appendix B. A total of six cross-sections were surveyed, two on the fly ash pond and four on the bottom ash pond. Plots of the cross-sections are shown in Appendix A. From the cross-section surveys, the approximate height of the Sioux bottom ash pond dam is 28 feet and the height of the fly ash pond dam is 21 feet. The dam height surveyed during this project is in close agreement with that found during the Phase I: AmerenUE Dam Inventory and Inspection Program project.

## **GEOTECHNICAL FIELD INVESTIGATION AND LAB TESTING**

Geotechnical field investigations were conducted using rotary drilling and cone penetrometer test (CPT) soundings. The quantity of borings and soundings, and the approximate locations at the power station are shown in Figure 1. The boring locations were selected by RJ based on previous experience at these locations, to fill in gaps where there was no subsurface data, slope geometry and to provide soil profiles representative of as much of the embankment as possible. The elevations of the ground surface at the boring locations were measured by Zahner and Associates, Inc. The borings were made by Terra Drill, Inc. of Dupon, Illinois, as a subcontractor to Reitz & Jens. The borings were advanced through the soil using 4.25-in. I.D. hollow-stem augers. Mud rotary drilling was necessary in all 3 of the auger drilling locations. Holes were backfilled with cement grout, which was tremied from the bottom to the top.

The CPT soundings were also made by Terra Drill, Inc. using a Geo-probe rig, under a subcontract with Reitz & Jens. The cone penetrometer consists of a 1.5-inch diameter, 100 MPa capacity, electronic piezocone (CPTu), which records tip pressure, sleeve friction and porewater pressure as it is hydraulically pushed into the ground. The testing was carried out according to ASTM D5778. The holes were backfilled the same day with Bentonite pellets.

The field investigation was done under the direction of a Reitz & Jens' geological engineer or geotechnical technician, who determined the sampling intervals and the termination depths, operated the CPT equipment, and logged the borings. The boring logs for the Sioux Power Station are presented in Figures 2-1 to 2-2. Logs of the CPT soundings are presented in Figures 3-1 to 3-6. The keys and notes for the boring logs and CPT soundings are shown in Figures 2-0 and 3-0, in that order.

Samples of subsurface materials were obtained using rotary drilling methods at about 2.5-foot intervals for the first 10 feet, at 5-foot intervals below 10 feet. Two types of samplers were used: 1) a hydraulically pushed, 3-in. O.D., thin-walled Shelby tube sampler (ASTM D-1587); and 2) a 2-in. O.D., split-spoon sampler driven by an automatic hammer in conjunction with a Standard Penetration Test (ASTM D-1586). Published tests have shown that the blow counts from a Standard Penetration Test (SPT) using an automatic hammer are about 75% of the blow counts obtained using a manual 140-lbs. drop hammer, rope and cathead. Manual SPT hammers have been used to develop correlations between SPTs and soil properties, therefore, the blow counts, or N-values, from an automatic hammer should be increased by about one-third in order to use such correlations. The uncorrected blow counts are shown on the boring logs. The disturbed split-spoon samples obtained were visually classified in the field and sealed in glass jars to prevent loss of moisture, for later testing in the laboratory. The relatively

undisturbed Shelby tube samples were sealed in the tubes and were extruded from the tubes immediately prior to testing in the lab.

All of the recovered samples were visually described in our laboratory in general accordance with the Unified Soil Classification System and the Standard Test Method for Classification, Description, and Identification of Soils (ASTM D-2487 and D-2488). Index tests were also performed and included: water content and dry unit weight tests (ASTM D-2216). The results of these index tests appear on the individual boring logs. Unconsolidated undrained (UU) triaxial compression tests (ASTM D2850) and consolidated undrained (CU) triaxial compression tests (ASTM D-4767) with pore pressure measurement were performed on selected Shelby tube samples of the fine grained samples, to obtain better measurements of the *in situ* total and effective shear strength properties. The results of the UU and CU triaxial shear strength tests are presented with the boring logs in Figures 2-3 to 2-6.

The field data from the CPT soundings were analyzed in the office using the program CPT-pro, Ver. 5.49 by Geosoft. The program automatically applies corrections for depth, and post/pre-data collection baseline readings. These corrected field data are plotted in the CPT logs, which are field tip resistance ( $q_c$ ), sleeve friction ( $f_s$ ) and pore water pressure ( $u_2$ ). Soil type was determined based upon the Robertson (1986) method<sup>1</sup>. Undrained shear strength ( $s_u$ ) was calculated for cohesive materials based upon the Lunne (1997) method<sup>2</sup>. Equivalent Standard Penetration Test (SPT)  $N_{60}$  values were calculated using procedures recommended by Robertson (1986)<sup>1</sup>. The equivalent  $N_{60}$  values were used to verify the computed internal friction angle ( $\phi$ ) in sands and  $s_u$  in fine-grain soils. The estimate of  $\phi$  in coarse soils was based upon the measured  $q_c$  values using Bowles (1996).<sup>3</sup> The computed parameters  $N_{60}$ ,  $s_u$  and  $\phi$  are also plotted in the CPT logs.

## **PIEZOMETER INSTALLATION AND MONITORING**

Temporary piezometers were installed to help define the line of seepage through the dam. Two piezometers were installed at Sioux. The piezometers were located as close to the downstream crest as possible, with the tips located in the lower most embankment fill above the native soils. The locations of the piezometers are shown in Figure 1, and descriptions of the tip elevation are noted in the boring logs. PZ-1 was located near the northwest corner of the bottom ash pond. P-8 (PZ) was located along the west side of the bottom ash pond, in an area where seepage has been observed during prior inspections of the embankment by Ameren personnel.

PZ-1 was constructed using 1-inch inside diameter Schedule 40 PVC pipe and P-8 was constructed with 3/4" Schedule 40 PVC pipe. The smaller diameter pipe was necessary in P-8 because it was installed in a CPT sounding hole. The piezometers had a 0.010-inch factory machine-slotted screen and were capped with a flush mount well protector. The bottom 10 feet of the piezometers were screened and backfilled with filter sand.

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<sup>1</sup> Robertson, P.K., et al. (1986), "Use of Piezometer Cone Data," *Proceedings of the ASCE Specialty Conference In Situ 86: Use of In Situ Tests in Geotechnical Engineering*, ASCE.

<sup>2</sup> Lunne, T., Robertson, P.K. and Powell, J.J.M. (1997). *Cone Penetration Testing in Geotechnical Practice*. Published by Blackie Academic \* Professional.

<sup>3</sup> Bowles, Joseph E. (1996). *Foundation Analysis and Design*. 5<sup>th</sup> ed., McGraw-Hill, page 180.

Readings were obtained from the piezometers and compared to the pool elevation. A table containing the piezometer readings is shown below. The temporary piezometers were removed after several readings were obtained and the holes were grouted close with cement grout.

Sioux Power Station

Date	Piezometer	Reading	Groundwater Elevation (ft)	Ground Surface Elevation (ft)	Tip Elevation (ft)	Pond Elevation (ft)
6/28/2010	PZ-1	15.7	427.3	443.0	423.5	436.2
8/2/2010	PZ-1	17.4	425.6	443.0	423.5	-
8/30/2010	PZ-1	19.8	423.2	443.0	423.5	435.5
10/8/2010	PZ-1	20.8	422.3	443.0	423.5	434.0
8/30/2010	P-8	15.7	428.7	444.4	426.5	435.5
10/8/2010	P-8	17.1	427.3	444.4	426.5	434.0

### **SIoux POWER STATION**

The Sioux Power Station is located in northeastern St. Charles County, Missouri in the floodplain of the Mississippi and Missouri Rivers. The plant is east of the City of Portage Des Sioux and west of the City of West Alton. The Mississippi River is adjacent to the plant and to the north at approximately river mile 210 above the confluence with the Ohio River. Poeling Lake and Brick House Slough of the Mississippi River lie to the west and north. The floodplain is continuous to the east and extends approximately 2 miles south to the Missouri River. The Sioux watershed is impounded by two dams to form the Bottom and Fly Ash Ponds. The Sioux Plant dams are single stage industrial dams. The Bottom Ash Pond dam impounds an area of approximately 47-acres. The Fly Ash Pond dam impounds an area of approximately 60-acres. These areas were estimated from aerial photos. The length of the perimeter of the dam measured along the crest for the Bottom Ash and Fly Ash Ponds is 6,600-lineal-feet (lf) and 7,675-lf respectively.

The Fly Ash dam was constructed in the 1990's. The upstream slopes of the Fly Ash dam are constructed of compacted earth fill at 3 (H) to 1 (V) and are lined with a 60 millimeter high-density polyethylene liner (HDPE). The upstream slopes were constructed from the top and over the upstream slope of an existing railroad and roadway embankment. The existing slopes of the railroad and roadway embankments are typically 2 (H) to 1 (V) and form the downstream slopes. A short section at the northwest corner of the dam was constructed with new downstream slopes at 3 (H) to 1 (V).

The Bottom Ash dam was constructed in the 1960's and consists of compacted earth fill but at 2 (H) to 1 (V). The Bottom Ash Pond is unlined. No data was provided regarding the initial geotechnical design assumptions or construction criteria used for the dams. The original design bottom elevation of the Bottom Ash Pond was elevation 400-feet.

### **Fly Ash Pond**

The top of the fly ash pond dam was surveyed along the extents shown in Figure 1. The crest elevation ranged from 441.2 to 444.3-feet. A plot of the elevation profile along the crest of the dam is also shown in Appendix B. Two cross-sections were also surveyed, and showed upstream slopes of approximately 3 (H) to 1 (V) and downstream slopes of approximately 2 (H) to 1 (V) and 2.5 (H) to 1 (V). The

approximate crown width varies but is generally between 30 and 40 feet. Drawings showing the measured cross-sections are presented in Appendix A.

CPT soundings were conducted at 2 locations along the fly ash pond. Both locations were in the crest of the dam and were advanced to a depth of 50 feet. A third sounding was planned at the toe, but due to floodwaters and soft saturated soils it was not conducted. Soundings through the crest revealed the embankment fill to be 1 to 3 foot thick alternating layers of sand, silt and clay to a depth of approximately 15 to 16 feet. For modeling purposes we modeled the embankment as an upper and lower fill. We assumed the  $\phi$  of the upper and lower fill to be  $25^\circ$  and  $28^\circ$ , in that order.

Firm to stiff clay soil was then encountered beneath the embankment fill to depths of 22 to 26 feet. A CU test on similar material obtained from a location near the bottom ash pond yielded an effective cohesion of 350 psf and a  $\phi$  of  $23^\circ$ . Underlying the clay was silty sand and sand. Based on the CPT soundings, the  $\phi$  of the silty sand and sand ranged from  $27.5^\circ$  to  $30^\circ$ . These soils generally made up the top 10 to 15 feet of the foundation. The foundation soils became increasingly coarse and dense with depth. The CPT soundings were terminated in sand or gravelly sand that has an estimated  $\phi$  of  $35^\circ$ .

### **Bottom Ash Pond**

An elevation profile was run on the crest of the bottom ash pond along the extents shown in Figure 1. The elevation ranged from 442.6 to 445.5-feet. The complete elevation profile is presented in Appendix B. Three cross-sections were surveyed by the professional land surveying sub-consultant and one additional section was surveyed by RJ. These cross-sections are also shown in Appendix B, and show that the upstream and downstream slopes are approximately 2 (H) to 1 (V). The crown width varies from approximately 13 to 20 feet.

Two rotary borings and two CPT soundings were conducted in the crest and two CPT soundings were conducted at the toe of the bottom ash pond. The location of these borings is shown in Figure 1. The embankment fill consists of very soft to stiff clay, silt and sand layers ranging in thickness from 0.5 to 4 feet in thickness. A CU test on an undisturbed sample obtained in the upper 15 feet showed a  $\phi$  of  $26^\circ$  and effective cohesion of 100 pcf. The soil strengths measured using the CPT soundings were in general agreement with the test data obtained from the CU test.

The top 10 to 12 feet of the foundation soil is high plastic clay or silty clay. The clay is firm to stiff. An undisturbed sample was also obtained in the foundation soils at a depth of approximately 5 feet beneath the embankment fill. A CU test was run on a specimen taken from this sample and resulted in a  $\phi$  of  $23.5^\circ$  and effective cohesion of 350 psf. Beneath the clay, sand and silty sand was encountered to the termination depth. The sand was poorly graded and generally medium dense. Based on the CPT soundings, the  $\phi$  of the sand and silty sand ranged from  $30^\circ$  to  $35^\circ$ .

### **Slope Stability Analysis Results**

The stability of the fly ash pond slopes was analyzed using cross-section 5, and the steady-seepage and seismic load cases. The steady-seepage case was analyzed at normal and maximum pool, but it was assumed that no seepage occurs through the HDPE liner. The normal pool elevation was assumed at 438.0 feet. The maximum pool was assumed at approximately elevation 440.8, or the overtopping

elevation. For the seismic load case a horizontal acceleration of 0.05 g or 0.25 of the probable maximum acceleration (PMA) was added to the steady state seepage model. The seismic load was taken from 10 CSR 22-3 for St. Charles County (Zone E) and for an environmental site class III dam.

For the bottom ash pond, the slope stability of cross-section 1 was analyzed using the same load cases used for the fly ash pond. For the steady seepage case, piezometric data collected during this project was used to model the line of seepage and was assumed representative of the normal pool. The normal pool elevation was assumed at elevation 435.0 feet. The maximum pool was assumed at elevation 442.4. For the maximum pool, a theoretical line of seepage was created and adjusted slightly to mimic the seepage at normal pool.

The factor of safety for each load case and each section analyzed is summarized in the following table. Graphical depictions of the slope stability models and the analysis results are shown in Appendix B. For Class III Industrial dams the calculated factor of safety exceeds the minimum required by the MDNR for the fly ash pond. For the bottom ash pond the factor of safety for steady seepage at normal pool is less than that required by the MDNR. For the maximum pool and seismic load cases the minimum factor of safety required is met. The factors of safety presented in the table are representative of deep failure surfaces that would significantly impair the ability of the dam to function as intended. When shallow failure surfaces are considered the factor of safety rapidly degrades for all load cases, especially along the west side of the bottom ash pond.

**Sioux Power Station**

Load Case	Required Factor of Safety	Factor of Safety	
		Fly Ash Pond	Bottom Ash Pond
Full Reservoir, Steady Seepage	1.5	1.9	1.4
Maximum Reservoir, Steady Seepage	1.3	1.8	1.3
Earthquake, steady seepage, full reservoir	1.0	1.6	1.2

## Seepage Evaluation

During the initial stages of this project RJ was made aware of a seepage area near the toe of the embankment close to the northeast corner of the bottom ash pond. The scope of this project was expanded to analyze and monitor the seepage, and provide recommendations for the remediation of this area. The seepage area consisted of one area with concentrated or “piping” type flow. In the same area, several “pin” type seeps were also observed flowing at the same time as the larger seep.

The seepage area with concentrated flow was observed making sediment and a sample of the sediment yielded was obtained. The grain size of the sediment was quantified and is provided in Figures 2-7 to 2-10. A sandbag ring was constructed around the area with concentrated flow to provide estimates of flow rate, qualitatively estimate the sediment yield and slow the transport of sediment. The flow rate was measured with a 90° v-notched weir at 3 stages of the sandbag construction, or three different ponding levels above the seep. The bottom ash pond level was at approximately elevation 434 feet (roughly 1 to 2 feet lower than normal because of a plant outage) or 15 feet the elevation of the seep. The flow measurements are approximate due to seepage through and under the sandbags, but are a reasonable

estimate. A flow of approximately 5 gallons per minute (gpm) was measured. The flow at the normal pond level is probably higher, but was not measured. The table below presents the field measurements and the calculated flow rate.

Ponding Above Seep (ft)	Head Across Weir (ft)	Flow Rate (gpm)
0.50	0.12	5.05
1.50	0.10	3.56
2.25	0.08	2.4*

\*Estimated Value

The sandbag ring and weir were left in place after the flow measurements were concluded. Qualitative monitoring of sediment yield was conducted with several visits to the site. A small cone of sediment has accumulated around the “piping” type flow. Observations were partially obstructed by biological growth within the sandbag ring, the continued biological growth has prevented any additional monitoring.

In light of the seep, an additional section was surveyed by RJ and analyzed. A piezometer was installed near the downstream crest of the crown near this section (P-8). This section or the North cross-section is shown in Appendix A, and was analyzed for the steady seepage and seismic load cases. Using the piezometric data and the estimated head at the toe from flow monitoring, the line of seepage was estimated. The factor of safety for the steady seepage case was approximately 1.3 and for the seismic case was 1.1. The factor of safety for the steady seepage load case is below the minimum required by the MDNR.

Observations of the seep show that the sediment yield is intermittent. The history of the seepage area is unknown. We recommend constructing an inverted filter over the bank of the seepage area to help stop the migration of fines from within the embankment. The details of the filter are presented in Appendix C. The filter should generally consist of a two foot thick base layer of coarse sand above the existing ground surface. The coarse sand should be overlain with a two foot intermediate layer consisting of gravel. Four feet of rip rap is recommended at the surface of the filter to protect against wave and current erosion. The recommended gradations for the coarse sand, and gravel and rip rap are presented in Appendix C. A sketch of the approximate location, limits of the filter and a typical cross-section of the filter are also presented in this appendix.

A densification program is also recommended to remediate any potential voids caused by the transport of fines. The extent of the piping or severity of the problem has not been determined. If the densification program is not conducted, monitoring of the seepage area, and the area near the toe and slopes on the north side of the bottom ash pond should be conducted regularly. Recently bottom ash has been added to the upstream slope to increase the thickness of the dam opposite the seepage area. We recommend installing a permanent piezometer at the downstream crest in this area to determine if the additional fill is increasing the seepage path through the embankment and lowering the line of seepage.

## **CONCLUSIONS**

Slope stability analysis conducted on cross-section 5 for the fly ash pond showed the factor of safety for steady seepage and earthquake load cases meet the MDNR minimum required factor of safety for Class III industrial dams. For the bottom ash pond, the steady seepage load case at normal pool did not meet the minimum required by the MDNR for Class III industrial dams for cross-section 1 and the north cross-section. The factor of safety for steady seepage at the maximum pool and the seismic load case met the minimum required by MDNR. The slope stability analysis considered critical surfaces which would significantly impact the performance of the dam. For shallow failure surfaces the factor of safety is much lower, especially on the west side of the bottom ash pond. Although shallow failures may not immediately impact the performance of the dam, if left unchecked these problems can propagate or unravel the slope and become a significant hindrance to the operation of the pond and require considerable effort to repair. The embankment slopes should be maintained and inspected regularly so that shallow failures can be identified and repaired in a timely fashion.

The pond level and resulting line of seepage through the dam has a significant impact on the stability of the bottom ash pond slopes. We recommend keeping the pond level at or below the assumed normal pool elevation. For sustained pond levels above the assumed normal pool elevation piezometers should be installed to monitor the line of seepage through the embankment.

An inverted filter should be constructed over the downstream bank where seepage has been observed. The details of the inverted filter are provided in Appendix C. Monitoring of the seepage area should be continued. A densification program is recommended to remediate any potential voids caused by the transport of fines.

Please let us know if you have any questions regarding this report or any aspects of the project. We appreciate this opportunity to continue our working relationship with Ameren Missouri.

Sincerely,  
REITZ & JENS, Inc.



Donald S. Eskridge, P.E.  
Principal



Jeff Bertel, P.E.  
Project Engineer

The following figures are attached and complete this report:

Figure 1	Boring Location Map
Figure 2-0	Key to Boring Logs
Figures 2-1 to 2-2	Logs of Borings
Figures 2-3 to 2-6	Graphs of CU and UU tests
Figures 2-7 to 2-10	Particle Size Distribution Reports

Figure 3-0

Figure 3-1 to 3-6

Appendix A

Appendix B

Appendix C

Key to CPT Soundings

Logs of CPT Soundings

Cross-section

Elevation Profile

Graphical Depictions of Slope Stability Models

Inverted Filter Details

Copies submitted: 5



Elevation Profile Survey Limits  
Locations of Cross-section and Borings

# KEY TO BORING LOGS

Symbol Description

## KEY TO SOIL SYMBOLS



Crushed Limestone



Miscellaneous FILL



High plastic CLAY (CH)



Poorly-graded SAND (SP)



Low plastic Silty CLAY (CL)

## MISCELLANEOUS SYMBOLS



Water table during drilling



Boring continues



Moisture content (%)



N-value from Standard Penetration Test, ASTM D-1586 (blows/ft)



Shear strength from Pocket Penetrometer (tsf)

## SOIL SAMPLERS



2-in. O.D. Split-Spoon



3-in. O.D. Shelby Tube

## Notes:

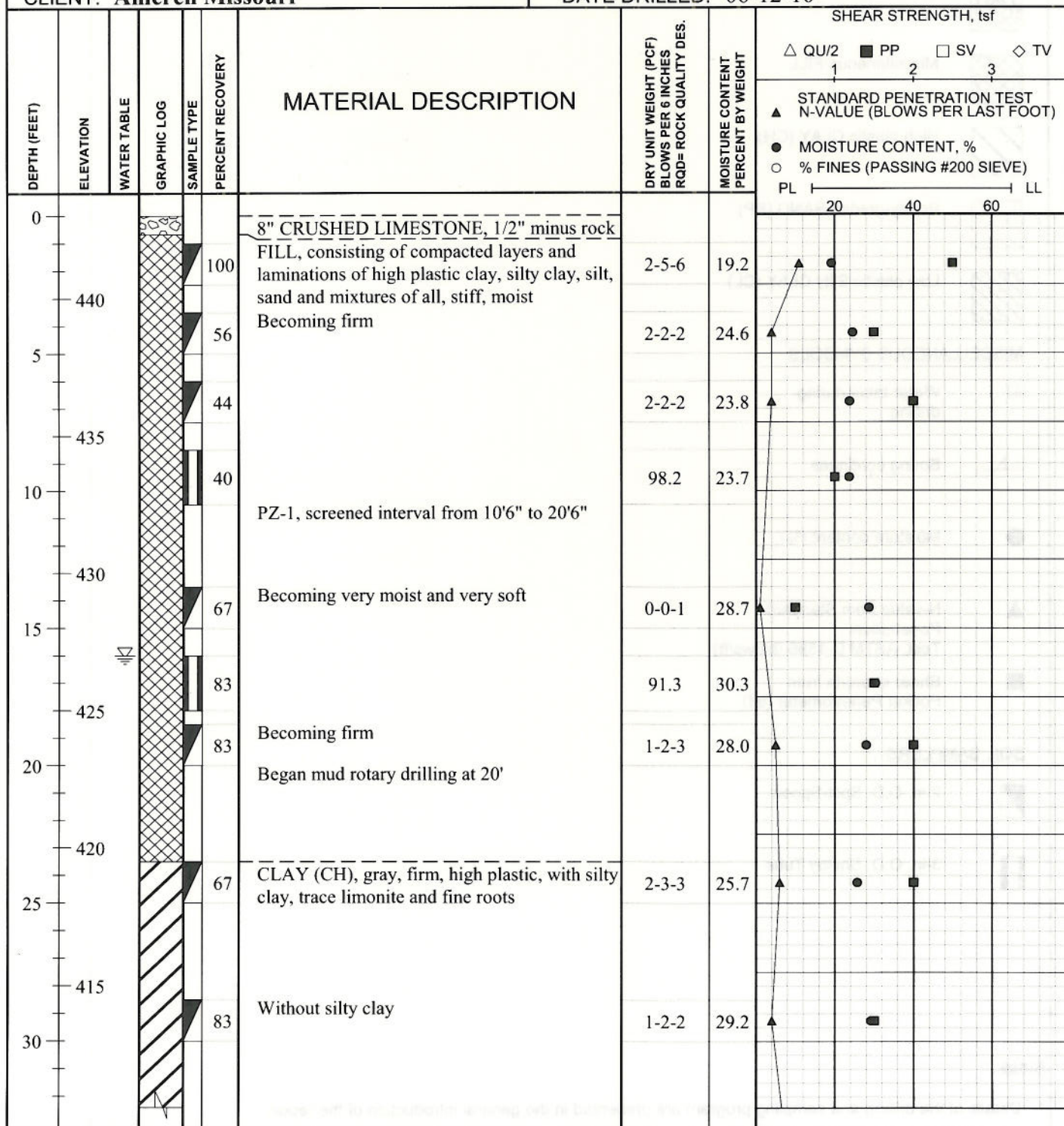
1. Details of the drilling and sampling program are presented in the general introduction of the report
2. Stratification lines shown on the log represent approximate soil boundaries; actual changes in strata may be gradual or occur between samples.

Figure 2-0

# BORING LOG PZ-1

**Ash Pond Stability**  
**Sioux Power Plant**  
CLIENT: **Ameren Missouri**

LOCATION: N 1121510.79 E 877737.340  
ELEVATION: 443.0 DATUM: NAVD88  
DATE DRILLED: 06-12-10



DRILLER: Terra Drill  
METHOD: 3.75" ID HSA  
TYPE OF SPT HAMMER: Automatic  
HAMMER EFFICIENCY (%): 86.3  
LOGGED BY: C. Cook

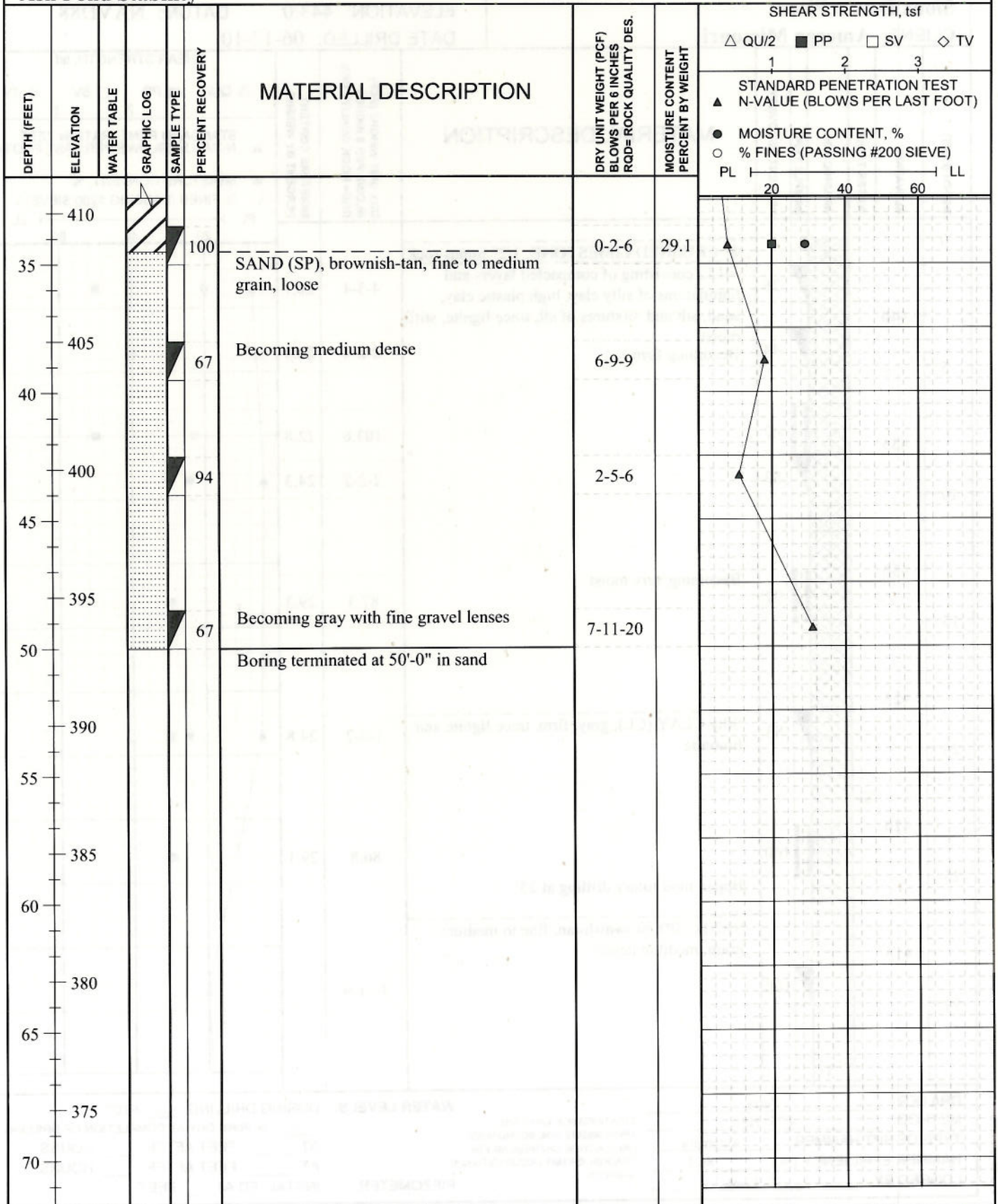
STRATIFICATION LINES ARE  
APPROXIMATE SOIL BOUNDARIES  
ONLY; ACTUAL CHANGES MAY BE  
GRADUAL OR MAY OCCUR BETWEEN  
SAMPLES.

**WATER LEVELS:** DURING DRILLING 16 FEET  
N BORING DRY AT COMPLETION OF DRILLING  
AT FEET AFTER HOURS  
AT FEET AFTER HOURS  
**PIEZOMETER:** INSTALLED AT FEET



# BORING LOG PZ-1

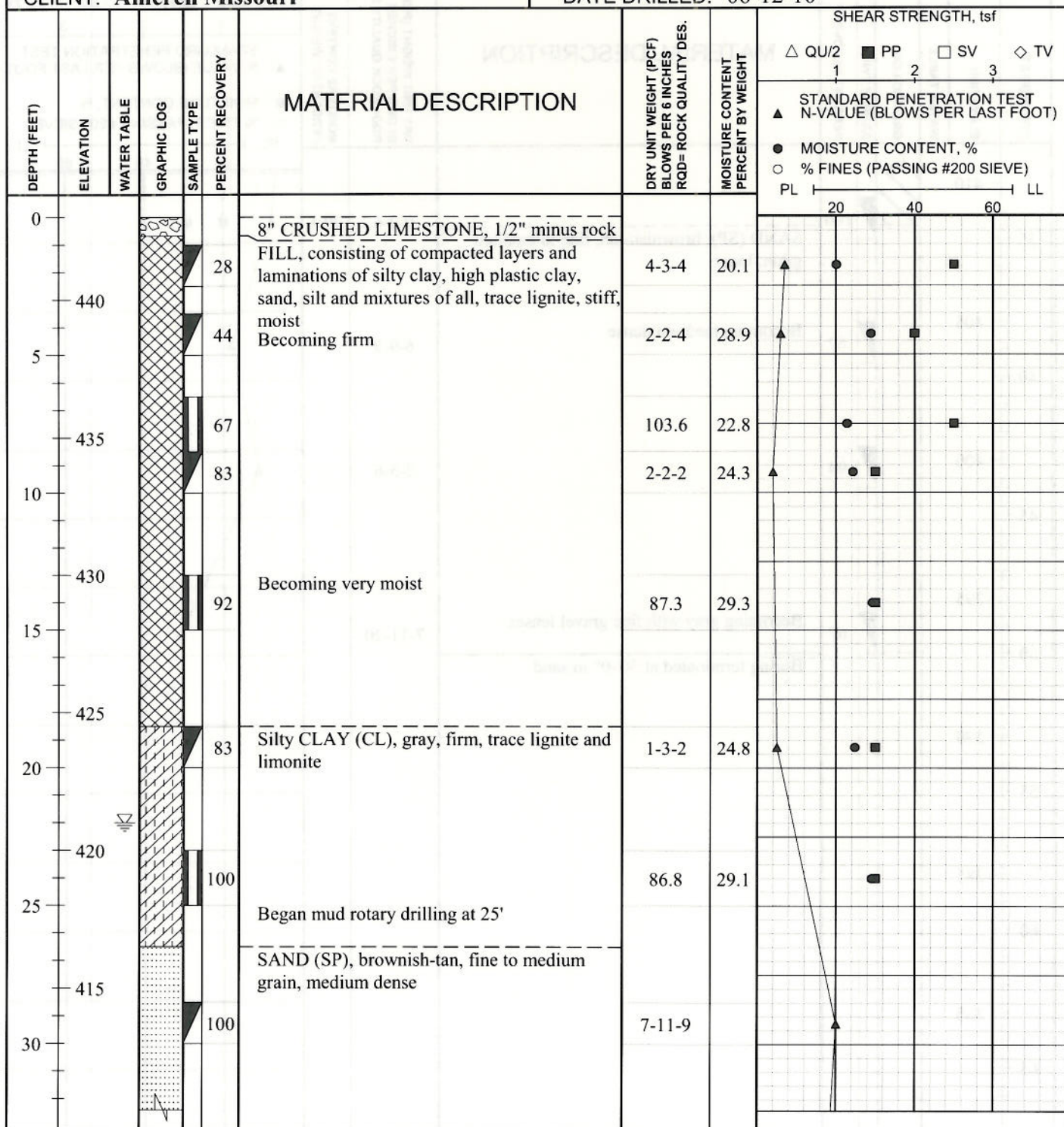
## Ash Pond Stability



# BORING LOG B-1

**Ash Pond Stability**  
**Sioux Power Plant**  
**CLIENT: Ameren Missouri**

**LOCATION: N 1122114.98 E 877818.565**  
**ELEVATION: 443.0 DATUM: NAVD88**  
**DATE DRILLED: 06-12-10**



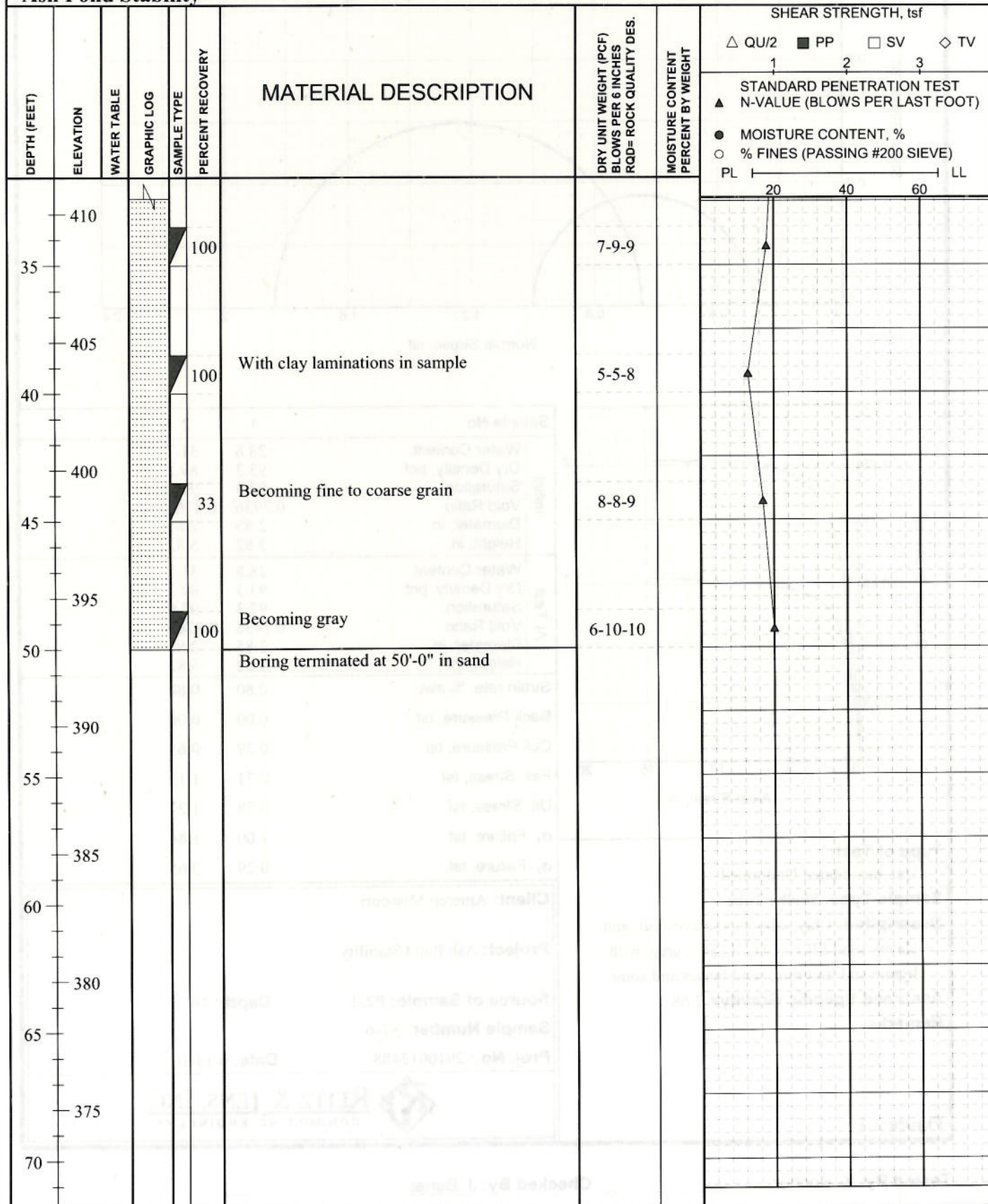
DRILLER: Terra  
 METHOD: 4.75" HSA  
 TYPE OF SPT HAMMER: Automatic  
 HAMMER EFFICIENCY (%): 86.3  
 LOGGED BY: C. Cook

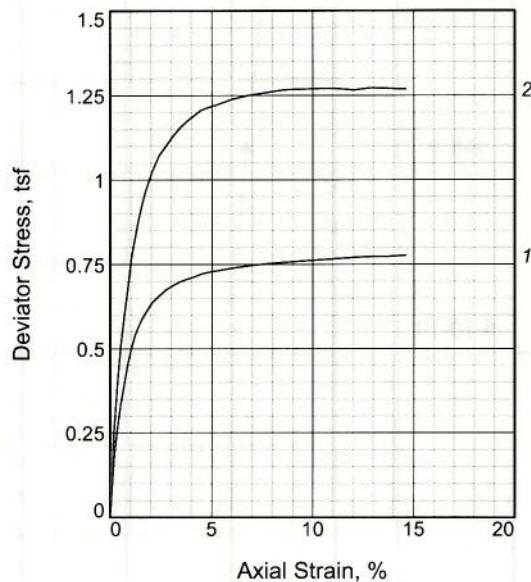
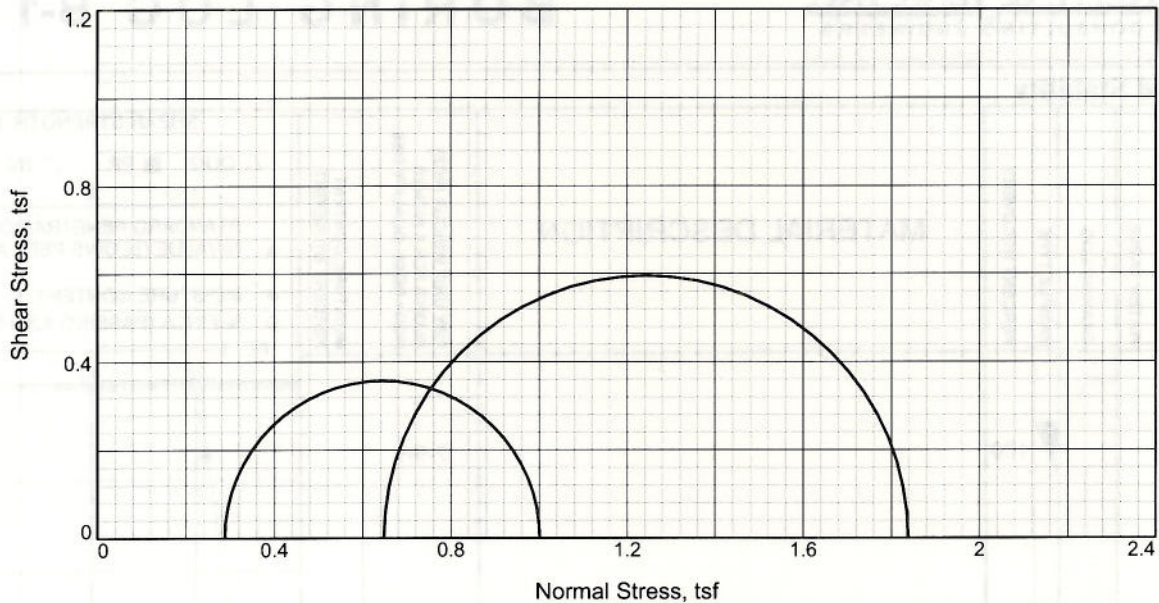
STRATIFICATION LINES ARE  
 APPROXIMATE SOIL BOUNDARIES  
 ONLY; ACTUAL CHANGES MAY BE  
 GRADUAL OR MAY OCCUR BETWEEN  
 SAMPLES.

**WATER LEVELS:** DURING DRILLING 22 FEET  
 N BORING DRY AT COMPLETION OF DRILLING  
 AT FEET AFTER HOURS  
 AT FEET AFTER HOURS  
**PIEZOMETER:** INSTALLED AT FEET

# BORING LOG B-1

## Ash Pond Stability





#### Type of Test:

Unconsolidated Undrained

**Sample Type:** Shelby Tube

**Description:** Clay, silty clay, clayey silt, and clayey sand FILL (CH-CL-SC), grey, with lignite and limonite, sand lenses and some

**Assumed Specific Gravity=** 2.68

**Remarks:**

**Figure 2-3**

Sample No.		1	2
Initial	Water Content,	28.8	31.7
	Dry Density, pcf	93.3	89.2
	Saturation,	97.3	97.0
	Void Ratio	0.7936	0.8765
	Diameter, in.	2.85	2.85
	Height, in.	5.82	5.82
At Test	Water Content,	28.8	31.7
	Dry Density, pcf	93.3	89.2
	Saturation,	97.3	97.0
	Void Ratio	0.7936	0.8765
	Diameter, in.	2.85	2.85
	Height, in.	5.82	5.82
Strain rate, %/min.		0.80	0.80
Back Pressure, tsf		0.00	0.00
Cell Pressure, tsf		0.29	0.65
Fail. Stress, tsf		0.71	1.19
Ult. Stress, tsf		0.78	1.27
$\sigma_1$ Failure, tsf		1.00	1.84
$\sigma_3$ Failure, tsf		0.29	0.65

**Client:** Ameren Missouri

**Project:** Ash Pond Stability

**Source of Sample:** PZ-1

**Depth:** 16

**Sample Number:** ST-6

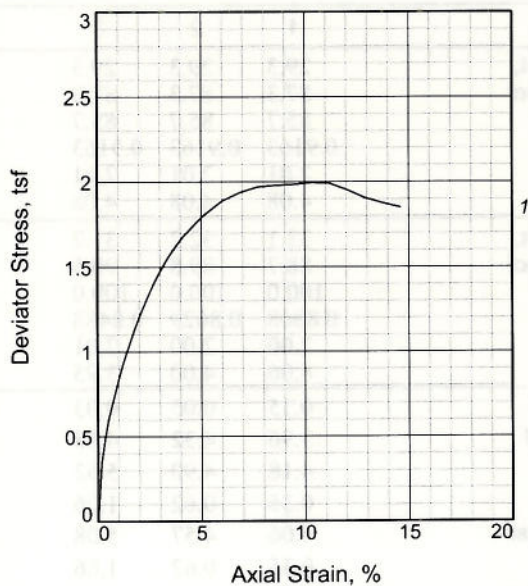
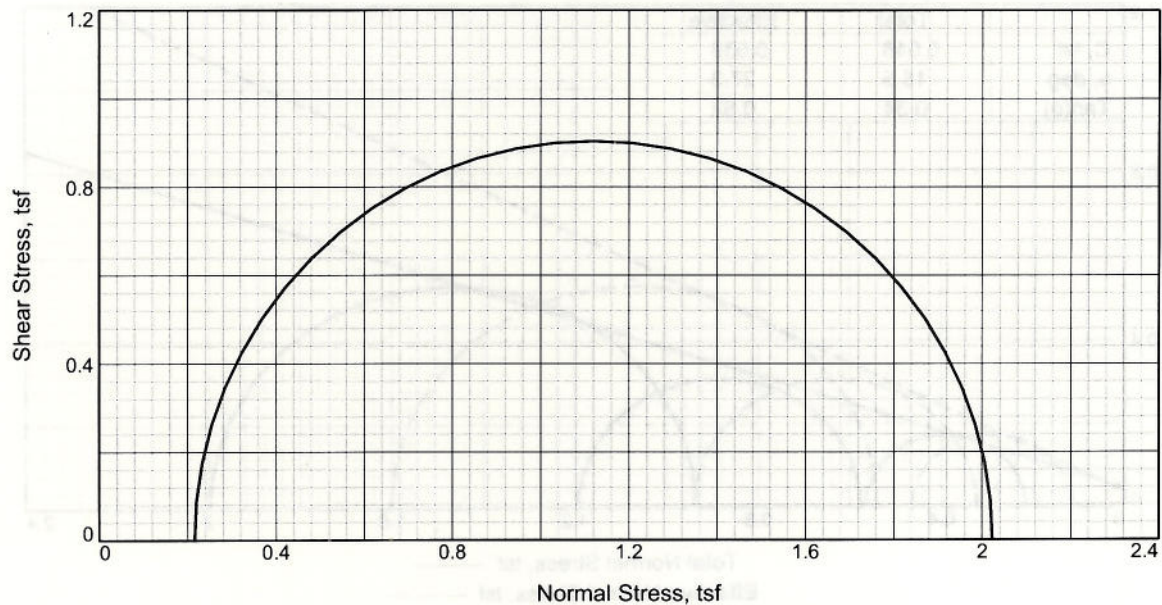
**Proj. No.:** 2010012488

**Date:** 6/14/10



**Tested By:** K. Kocher

**Checked By:** J. Bertel



Sample No. 1

Initial  
Water Content, 22.8  
Dry Density, pcf 103.6  
Saturation, 99.6  
Void Ratio 0.6146  
Diameter, in. 2.85  
Height, in. 5.82

At Test  
Water Content, 22.8  
Dry Density, pcf 103.6  
Saturation, 99.6  
Void Ratio 0.6146  
Diameter, in. 2.85  
Height, in. 5.82

Strain rate, %/min. 0.80

Back Pressure, tsf 0.00

Cell Pressure, tsf 0.22

Fail. Stress, tsf 1.81

Ult. Stress, tsf 2.00

$\sigma_1$  Failure, tsf 2.02

$\sigma_3$  Failure, tsf 0.22

#### Type of Test:

Unconsolidated Undrained

**Sample Type:** Shelby Tube

**Description:** Clay, silty clay, clayey silt, and sandly silty clay FILL (CH-CL-ML), grey, with lignite and limonite

**Assumed Specific Gravity=** 2.68

**Remarks:**

**Client:** Ameren Missouri

**Project:** Ash Pond Stability

**Source of Sample:** B-1

**Depth:** 6.5

**Sample Number:** ST-3

**Proj. No.:** 2010012488

**Date:** 6/14/10

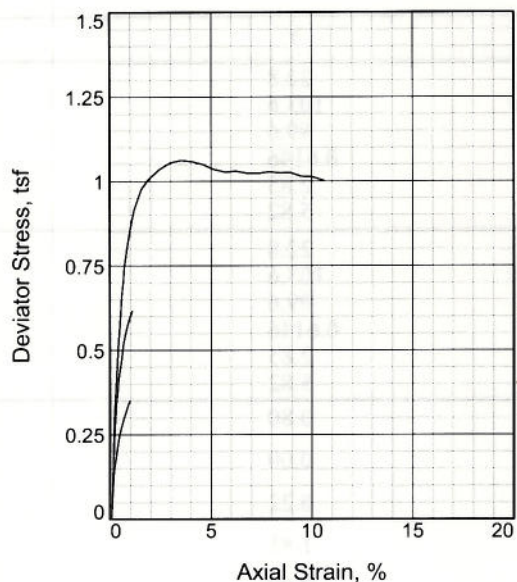
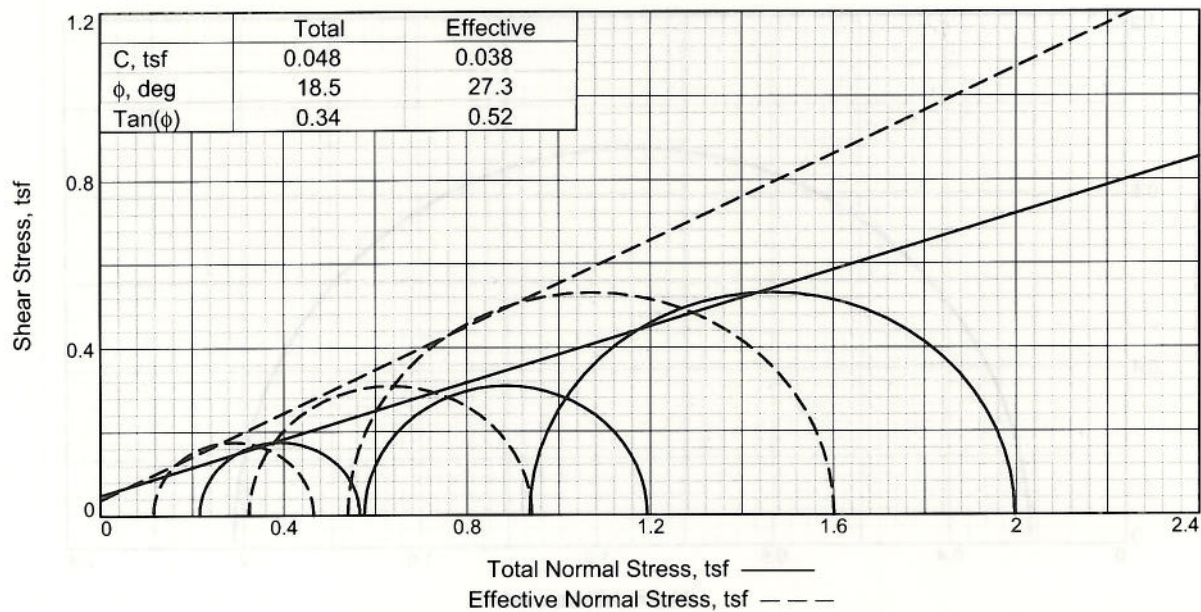


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CONSULTING ENGINEERS

Figure 2-4

Tested By: K. Kocher

Checked By: J. Bertel



Sample No.	1	2	3
Initial	Water Content,	29.3	29.3
	Dry Density, pcf	87.3	87.3
	Saturation,	85.7	85.7
	Void Ratio	0.9163	0.9163
	Diameter, in.	2.01	2.01
	Height, in.	4.08	4.08
At Test	Water Content,	33.1	32.2
	Dry Density, pcf	88.7	89.8
	Saturation,	100.0	100.0
	Void Ratio	0.8868	0.8629
	Diameter, in.	2.00	2.00
	Height, in.	4.06	4.00
1	Strain rate, %/min.	0.15	0.05
	Back Pressure, tsf	3.96	4.32
	Cell Pressure, tsf	4.18	4.90
	Fail. Stress, tsf	0.35	0.62
	Total Pore Pr., tsf	4.06	4.57
	Ult. Stress, tsf	0.35	0.62
	Total Pore Pr., tsf	4.06	4.57
	$\bar{\sigma}_1$ Failure, tsf	0.47	0.94
	$\bar{\sigma}_3$ Failure, tsf	0.12	0.32
		0.54	

#### Type of Test:

CU with Pore Pressures

**Sample Type:** Shelby Tube

**Description:** Silty clay, clayey silt, and clay FILL, grey, with sandy silt lenses, lignite, and limonite

**Assumed Specific Gravity=** 2.68

**Remarks:**

**Client:** Ameren Missouri

**Project:** Ash Pond Stability

**Source of Sample:** B-1

**Depth:** 13

**Sample Number:** ST-5

**Proj. No.:** 2010012488

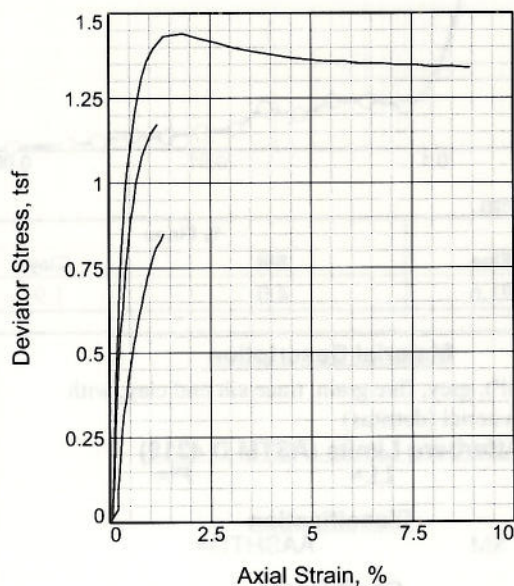
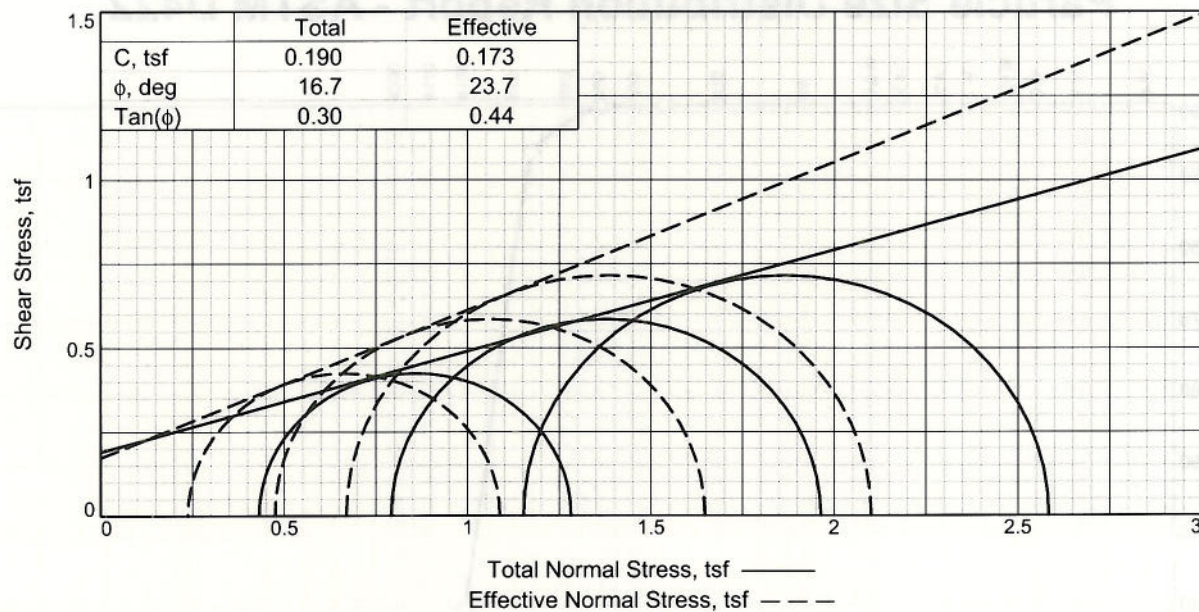
**Date:** 6/14/2010



Figure 2-5

Tested By: K. Kocher

Checked By: J. Bertel



Sample No.		1	2	3
Initial	Water Content,	29.1	29.1	29.1
	Dry Density, pcf	86.8	86.8	86.8
	Saturation,	84.2	84.2	84.2
	Void Ratio	0.9280	0.9280	0.9280
	Diameter, in.	2.02	2.02	2.02
	Height, in.	5.00	5.00	5.00
At Test	Water Content,	33.3	33.0	32.9
	Dry Density, pcf	88.4	88.7	89.0
	Saturation,	100.0	100.0	100.0
	Void Ratio	0.8923	0.8854	0.8807
	Diameter, in.	2.01	2.02	2.03
	Height, in.	4.97	4.90	4.84
Strain rate, %/min.		0.50	0.50	0.50
Back Pressure, tsf		3.96	4.32	5.04
Cell Pressure, tsf		4.39	5.11	6.19
Fail. Stress, tsf		0.85	1.17	1.43
Total Pore Pr., tsf		4.15	4.64	5.52
Ult. Stress, tsf		0.85	1.17	1.43
Total Pore Pr., tsf		4.15	4.64	5.52
$\bar{\sigma}_1$ Failure, tsf		1.09	1.65	2.10
$\bar{\sigma}_3$ Failure, tsf		0.24	0.48	0.67

#### Type of Test:

CU with Pore Pressures

**Sample Type:** Shelby Tube

**Description:** Silty CLAY (CL), grey-brown, with lignite and limonite

**LL=** 45

**Assumed Specific Gravity=** 2.68

**Remarks:**

**Client:** Ameren Missouri

**Project:** Ash Pond Stability

**Source of Sample:** B-1

**Depth:** 23

**Sample Number:** ST-7

**Proj. No.:** 2010012488

**Date:** 6-14-10



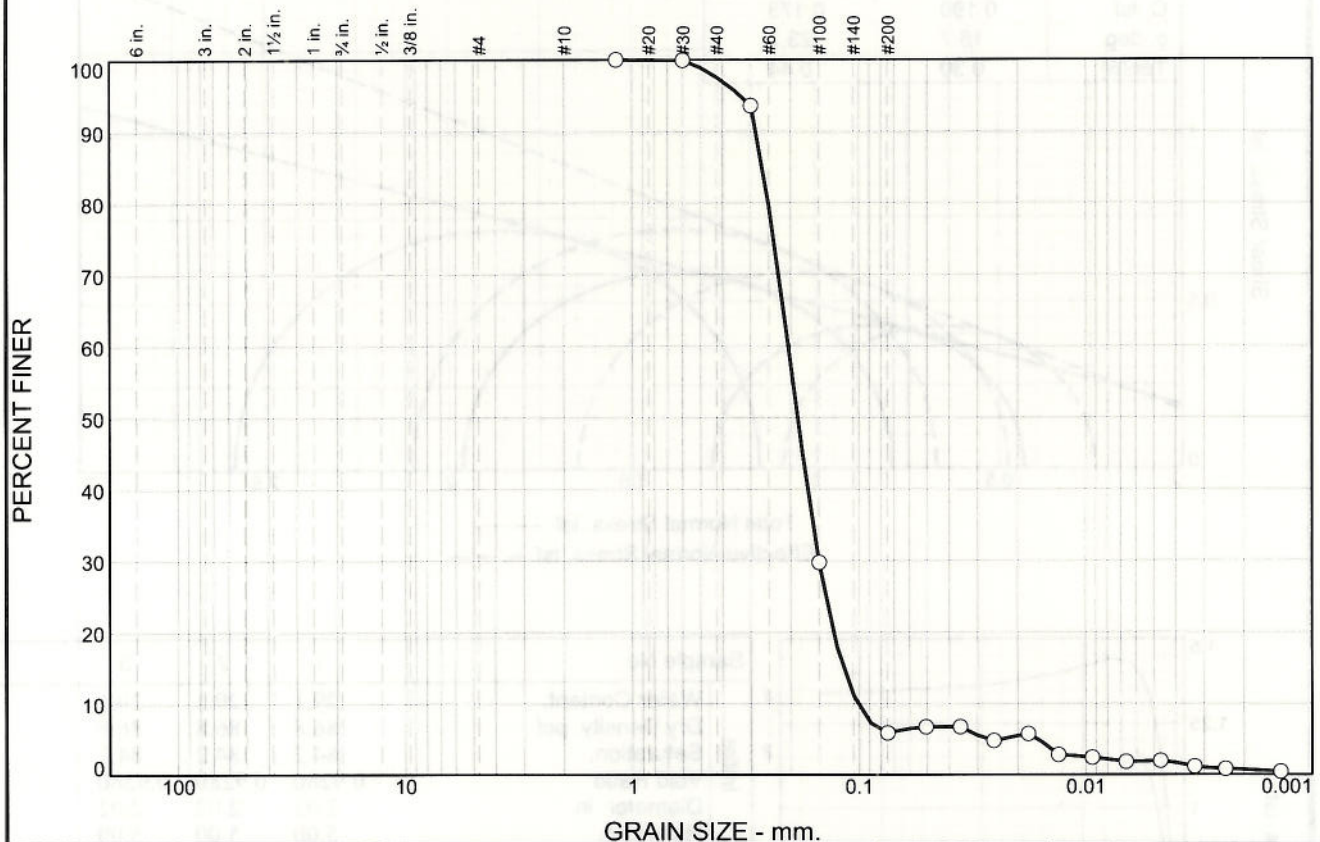
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CONSULTING ENGINEERS

Figure 2-6

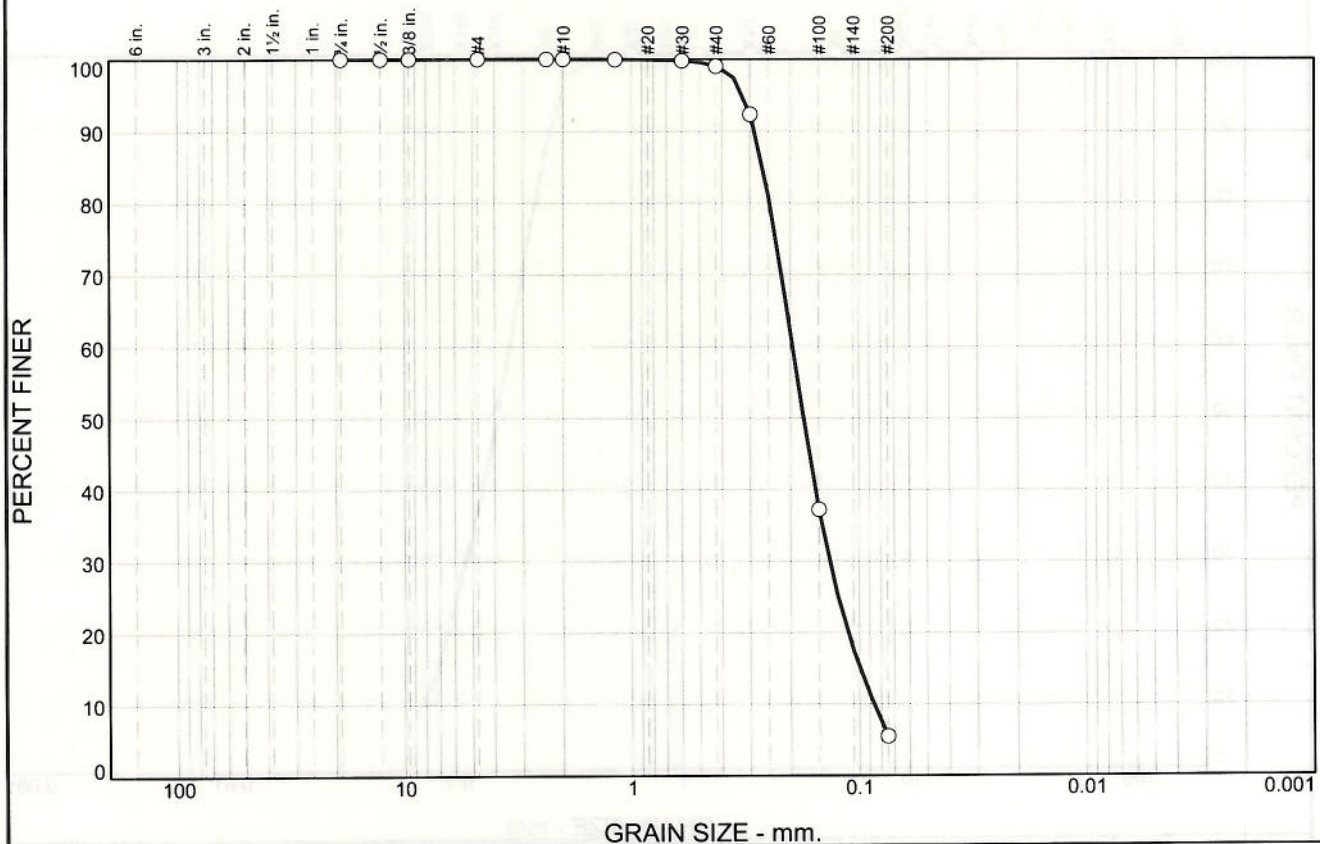
Tested By: K. Kocher

Checked By: J. Fouse

# Particle Size Distribution Report - ASTM D422



# Particle Size Distribution Report - ASTM D422



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	1.0	93.5	5.5	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/4	100.0		
1/2	100.0		
3/8	100.0		
#4	100.0		
#8	100.0		
#10	100.0		
#16	100.0		
#30	99.8		
#40	99.0		
#50	92.3		
#100	37.2		
#200	5.5		

\* (no specification provided)

## Material Description

SAND (SP), grey, fine grain, trace silt and clay, with organic material (detritus)

## Atterberg Limits (ASTM D 4318)

PL= LL= PI=

## Classification

USCS= AASHTO=

## Coefficients

D<sub>85</sub>= 0.2639 D<sub>60</sub>= 0.1955 D<sub>50</sub>= 0.1750  
D<sub>30</sub>= 0.1350 D<sub>15</sub>= 0.0994 D<sub>10</sub>= 0.0863  
C<sub>u</sub>= 2.26 C<sub>c</sub>= 1.08

Date Tested: 9/13/10 Tested By: J. Crose

## Remarks

Sample No.: Sample #1 Source of Sample: Sand Boil Location

Location:

Checked By: D. Eskridge

Title: Project Manager

Date Sampled: 9/9/10

Elev./Depth: Surface



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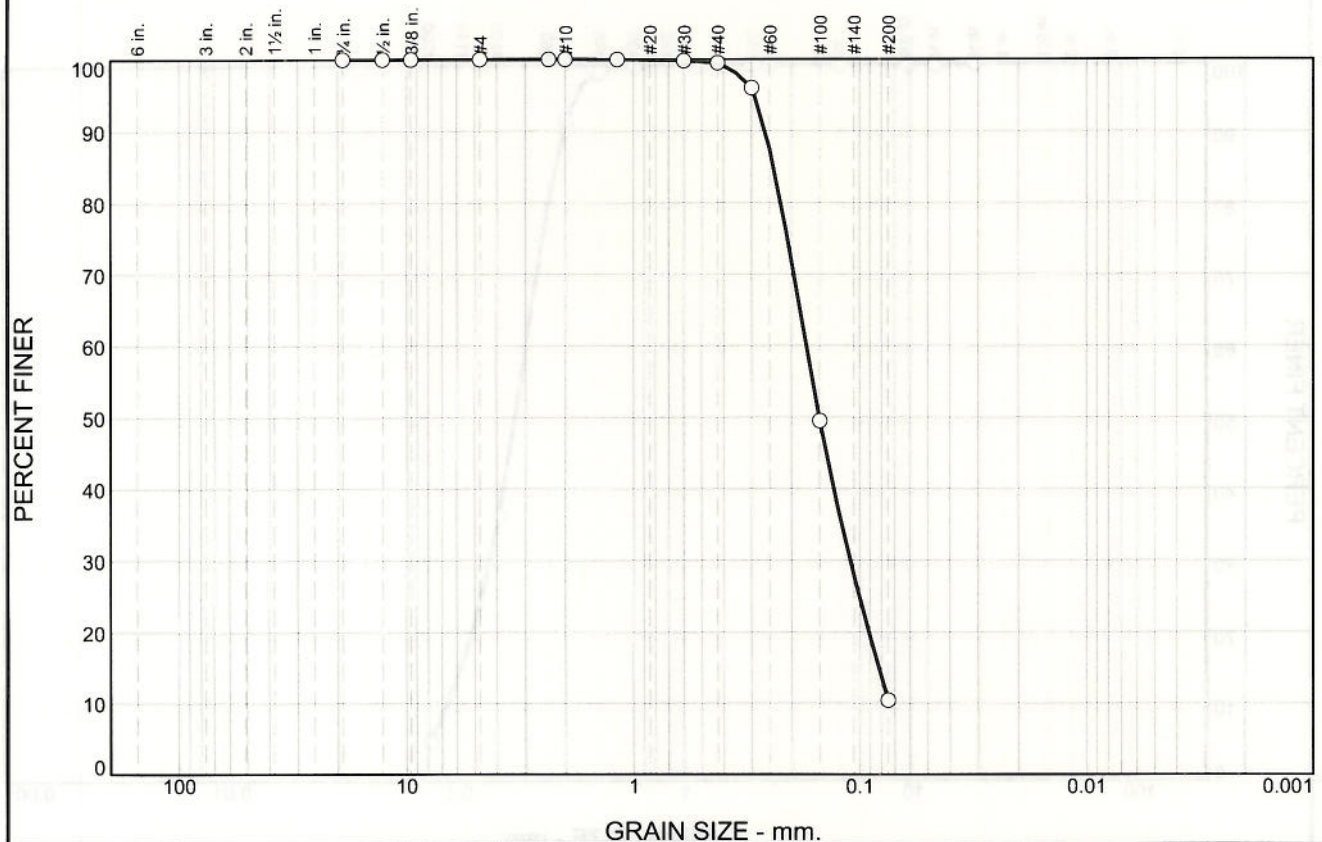
Client: Ameren Missouri

Project: Bottom Ash Pond Seepage

Project No: 2010012488

Figure 2-8

# Particle Size Distribution Report - ASTM D422



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.5	89.1	10.4	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/4	100.0		
1/2	100.0		
3/8	100.0		
#4	100.0		
#8	100.0		
#10	100.0		
#16	100.0		
#30	99.8		
#40	99.5		
#50	96.0		
#100	49.6		
#200	10.4		

\* (no specification provided)

## Material Description

SAND (SP-SM), grey, fine grain, with silt, clay, and organic material (detritus)

## Atterberg Limits (ASTM D 4318)

PL= LL= PI=

## Classification

USCS= AASHTO=

## Coefficients

D<sub>85</sub>= 0.2400 D<sub>60</sub>= 0.1720 D<sub>50</sub>= 0.1509  
D<sub>30</sub>= 0.1102 D<sub>15</sub>= 0.0824 D<sub>10</sub>=  
C<sub>u</sub>= C<sub>c</sub>=

Date Tested: 9/13/10 Tested By: J. Crose

## Remarks

Sample No.: Sample #2 Source of Sample: Sand Boil Location

Location:

Checked By: D. Eskridge

Title: Project Engineer

Date Sampled: 9/9/10

Elev./Depth: Surface



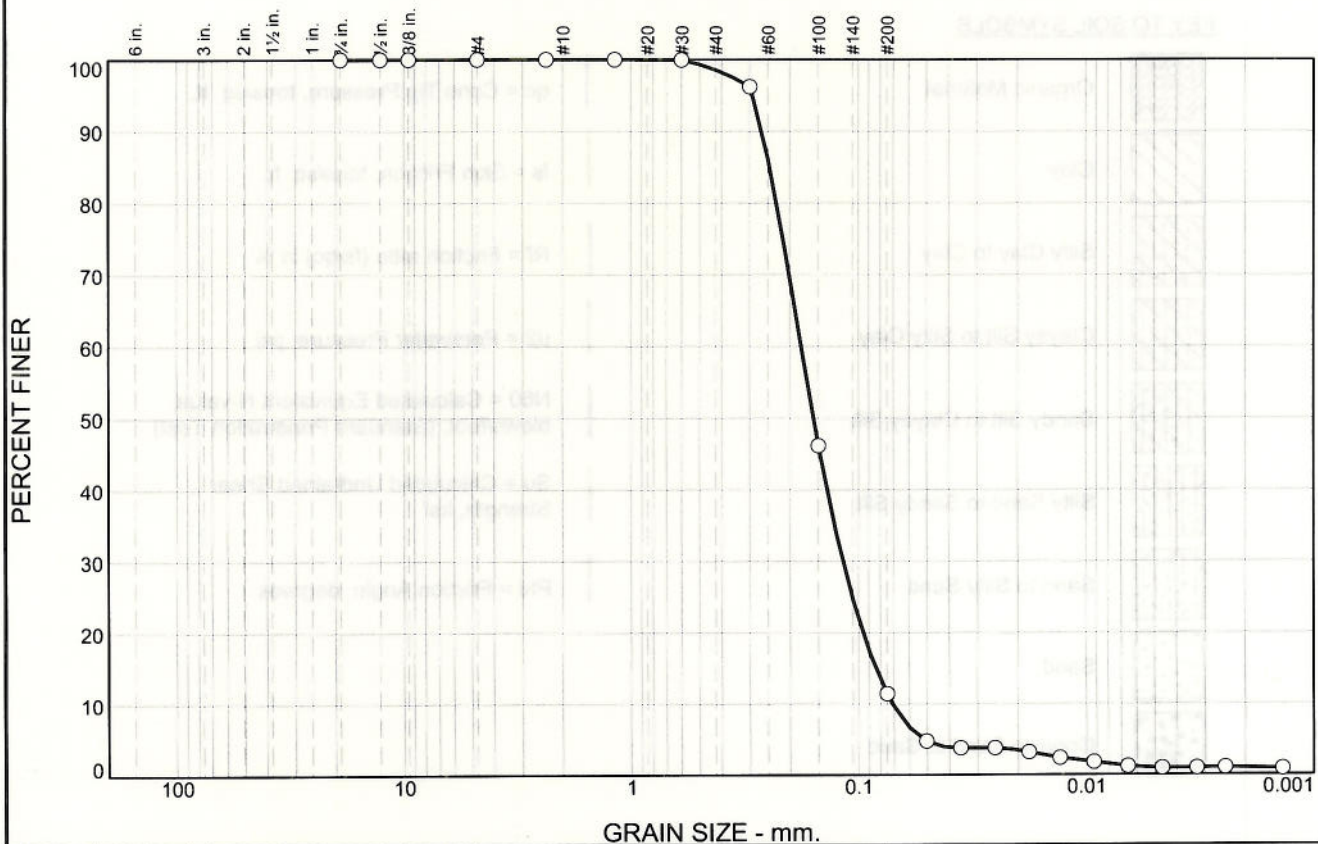
**REITZ & JENS, INC.**  
CONSULTING ENGINEERS

Client: Ameren Missouri  
Project: Bottom Ash Pond Seepage

Project No: 2010012488

Figure 2-9

# Particle Size Distribution Report - ASTM D422



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	1.4	87.1	10.5	1.0

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/4	100.0		
1/2	100.0		
3/8	100.0		
#4	100.0		
#8	100.0		
#16	100.0		
#30	100.0		
#50	96.2		
#100	46.2		
#200	11.5		

## Material Description

SAND (SP-SM), grey, fine grain, with silt, clay, and organic material (detritus)

## Atterberg Limits (ASTM D 4318)

PL= LL= PI=

## Classification

USCS= AASHTO=

## Coefficients

D<sub>85</sub>= 0.2456 D<sub>60</sub>= 0.1786 D<sub>50</sub>= 0.1577  
D<sub>30</sub>= 0.1172 D<sub>15</sub>= 0.0841 D<sub>10</sub>= 0.0708  
C<sub>u</sub>= 2.52 C<sub>c</sub>= 1.09

Date Tested: 9/13-15/10 Tested By: J. Crose, K. Kocher

## Remarks

\* (no specification provided)

Sample No.: Sample #2 Source of Sample: Sand Boil Location

Location:

Checked By: D. Eskridge

Title: Project Manager

Date Sampled: 9/9/10

Elev./Depth: Surface



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CONSULTING ENGINEERS

Client: Ameren Missouri

Project: Bottom Ash Pond Seepage

Project No: 2010012488

Figure 2-10

## LEGEND

Symbol Description

### KEY TO SOIL SYMBOLS



Organic Material



Clay



Silty Clay to Clay



Clayey Silt to Silty Clay



Sandy Silt to Clayey Silt



Silty Sand to Sandy Silt



Sand to Silty Sand



Sand



Gravelly Sand to Sand

$q_c$  = Cone Tip Pressure, tons/sq. ft.

$f_s$  = Skin Friction, tons/sq. ft.

$R_f$  = Friction ratio ( $f_s/q_c$ ) in %

$u_2$  = Porewater Pressure, psi

$N_{60}$  = Calculated Equivalent N-value, blows/foot, (Standard Penetration Test)

$S_u$  = Calculated Undrained Shear Strength, ksf

$\Phi$  = Friction Angle, degrees

### Notes:

1. Details of the drilling and sampling program are presented in the general introduction of the report.
2. Stratification lines shown on the log represent approximate soil boundaries; actual changes in strata may be gradual.

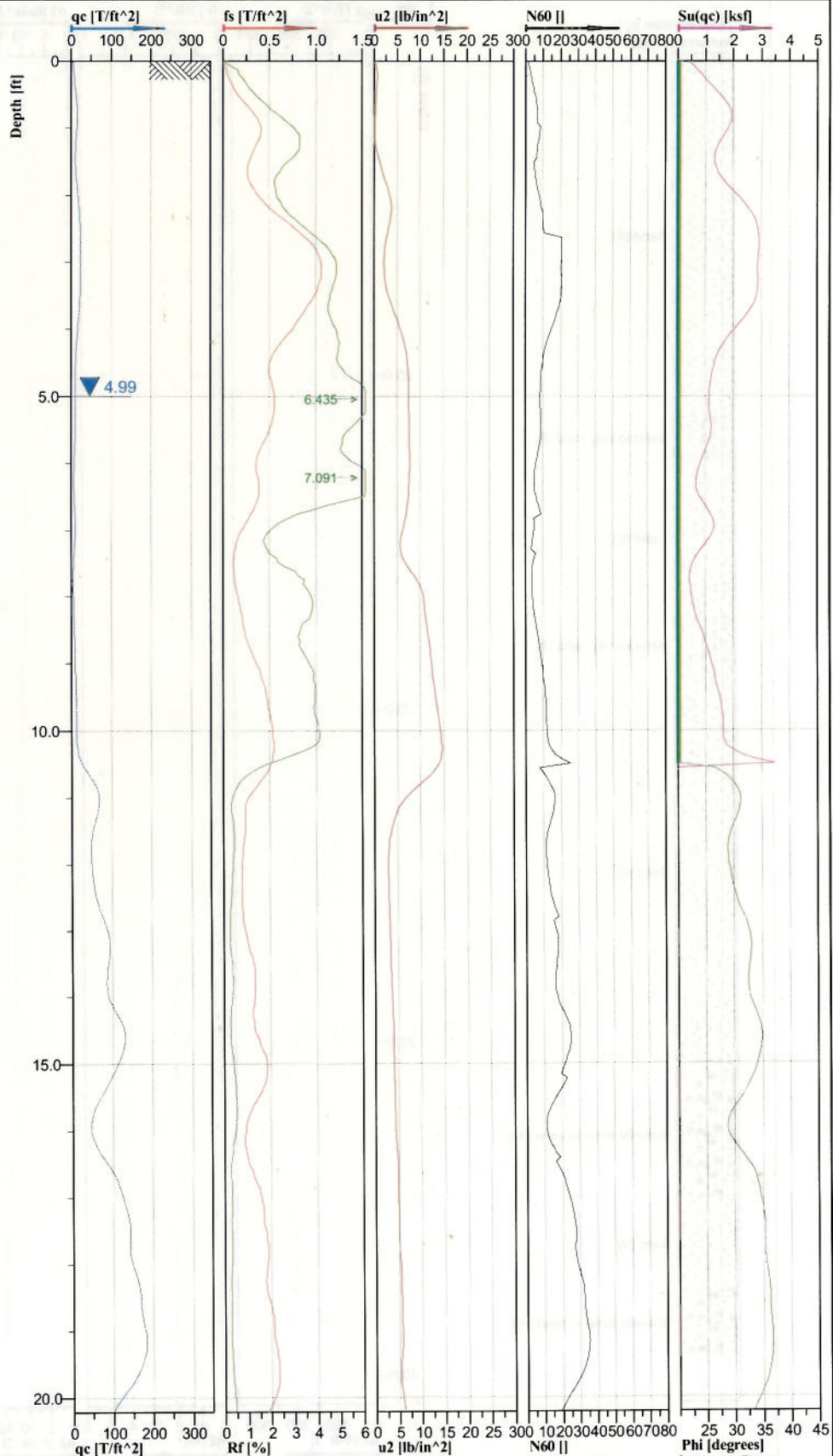
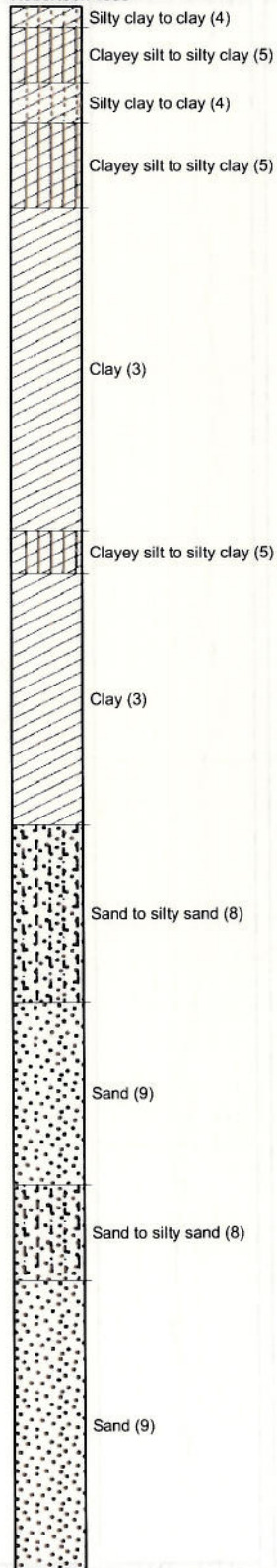
<sup>1</sup> Robertson et al. (1986) *Use of piezometer cone data*. Proceedings of the ASCE Specialty Conference: In Situ 86: Use of In Situ Tests in Geotechnical Engineering. ASCE 1986

<sup>2</sup> Lunne, T. Robertson, P.K. and Powell, J.J.M. (1997) *Cone Penetration Testing in Geotechnical Practice*, Published by Blackie Academic & Professional.

<sup>3</sup> Bowles, Joseph E. (1996) *Foundation Analysis and Design*. McGraw-Hill. 5<sup>th</sup> ed. Page 180.

Figure 3-0

Classification by  
Robertson 1986



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Cone No: 4274  
Tip area [cm<sup>2</sup>]: 10  
Sleeve area [cm<sup>2</sup>]: 150



Location: Sioux Power Plant	Position: X: 877872.87 ft, Y: 1122198.49 ft	Ground level: 425.98	Test no: P-1
Project ID: 2010012488	Client: Ameren Missouri	Date: 8/14/2010	Scale: 1 : 28
Project: 2010 Ash Pond Stability Analysis	Page: 1/2	Fig: 3-1	
	File: p-1.cpd		

Classification by  
Robertson 1986



Sand (9)

Sand to silty sand (8)

Sand (9)

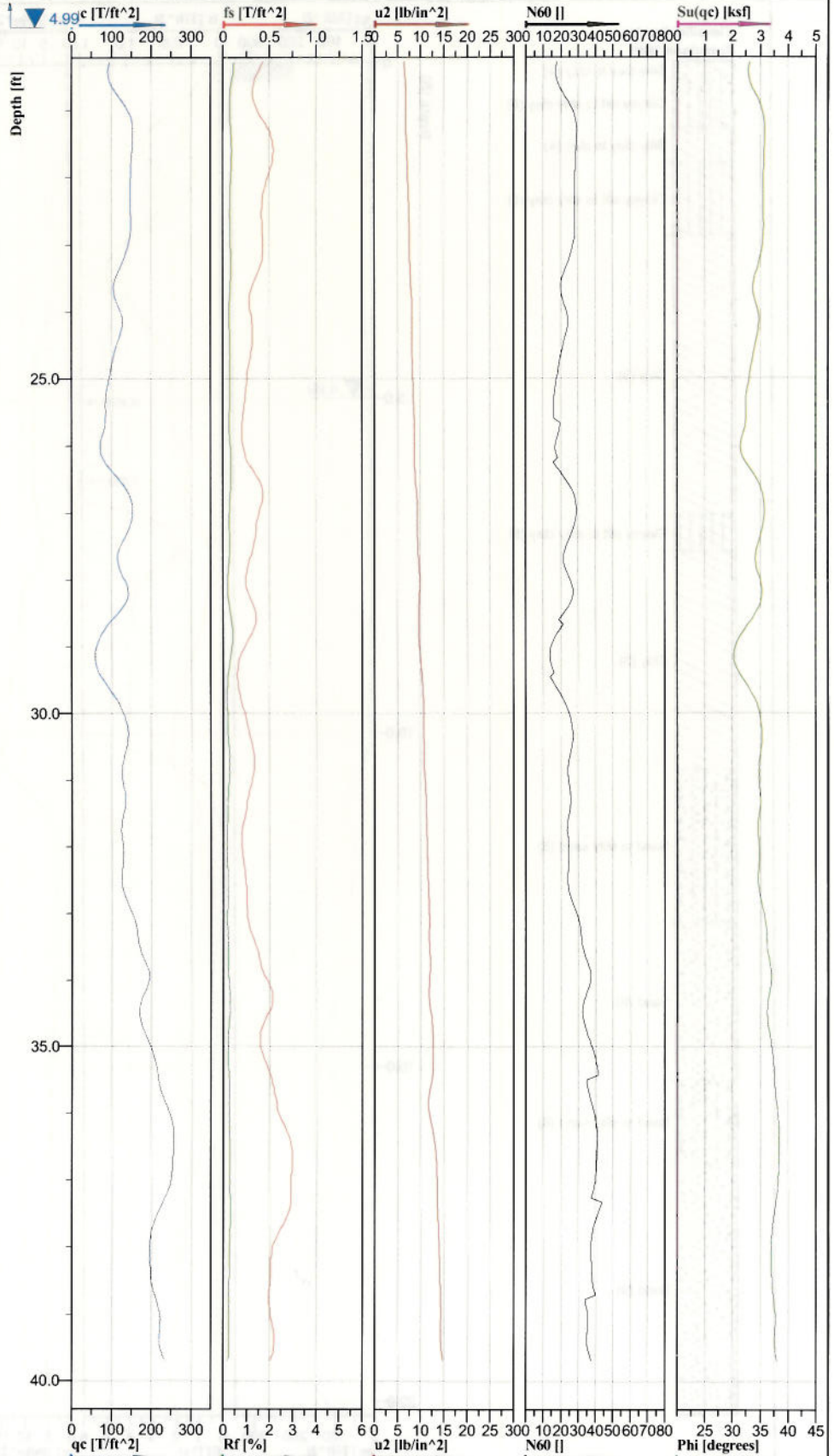
Sand to silty sand (8)

Sand (9)

Gravelly sand to sand (10)

Sand (9)

Gravelly sand to sand (10)

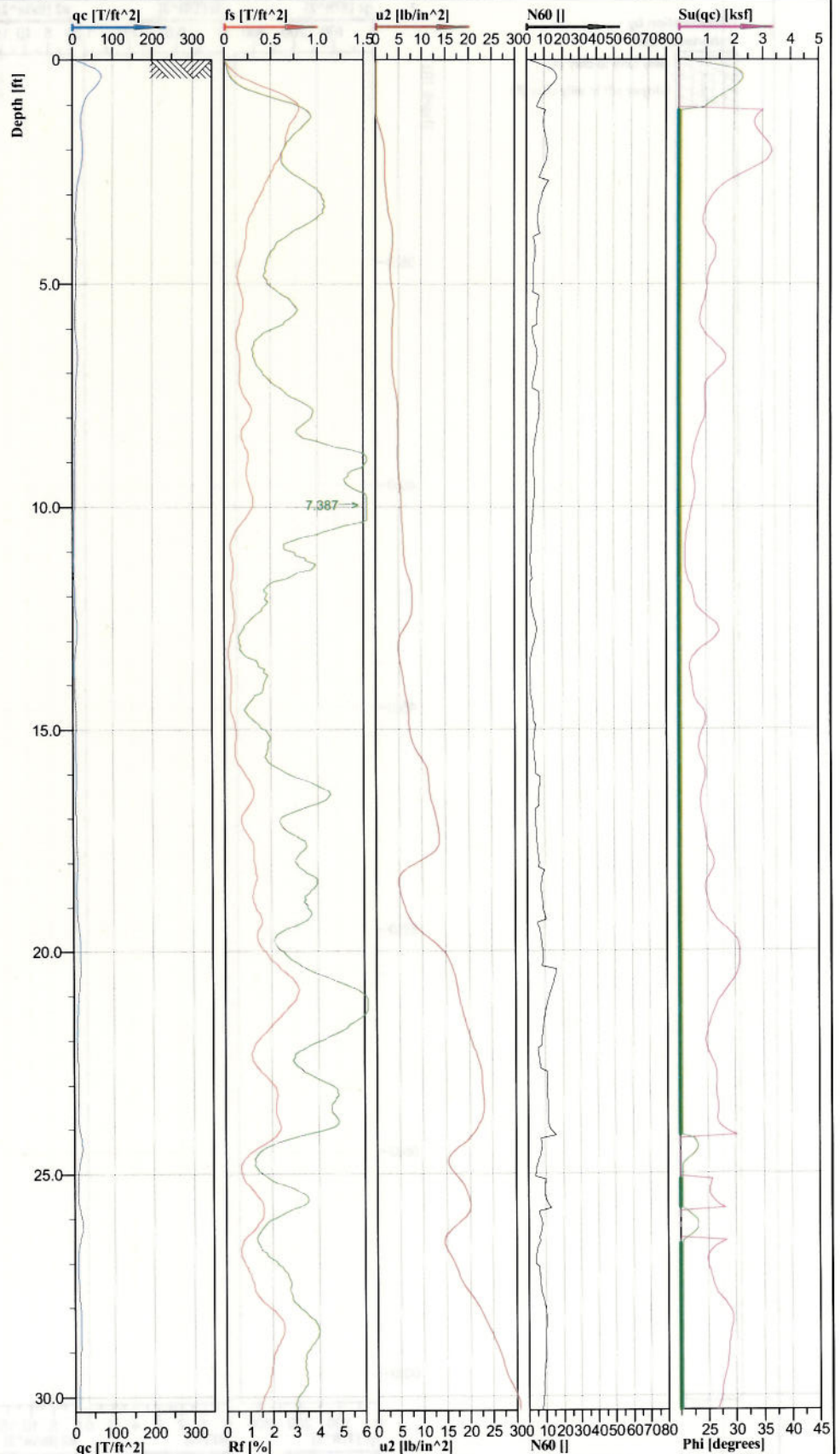
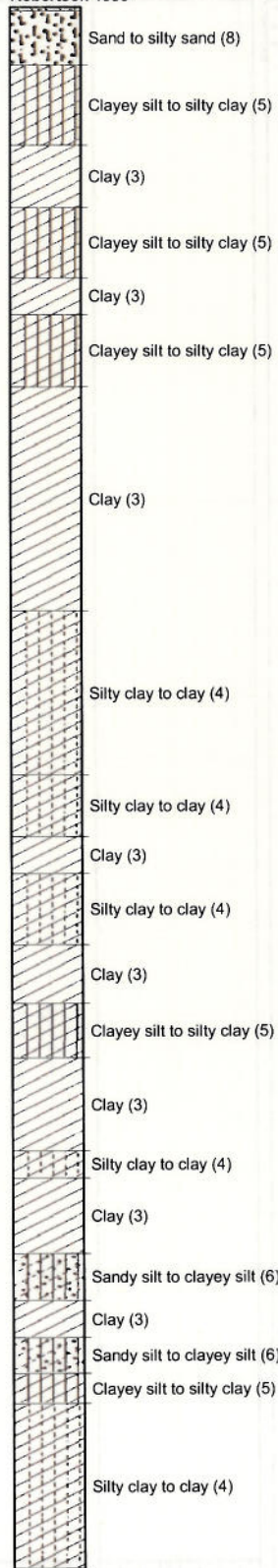


Cone No: 4274  
Tip area [cm<sup>2</sup>]: 10  
Sleeve area [cm<sup>2</sup>]: 150



Location: Sioux Power Plant	Position: X: 877872.87 ft, Y: 1122198.49 ft	Ground level: 425.98	Test no: P-1
Project ID: 2010012488	Client: Ameren Missouri	Date: 8/14/2010	Scale: 1 : 28
Project: 2010 Ash Pond Stability Analysis	Page: 2/2	Fig: 3-1	
		File: p-1.cpd	

Classification by  
Robertson 1986





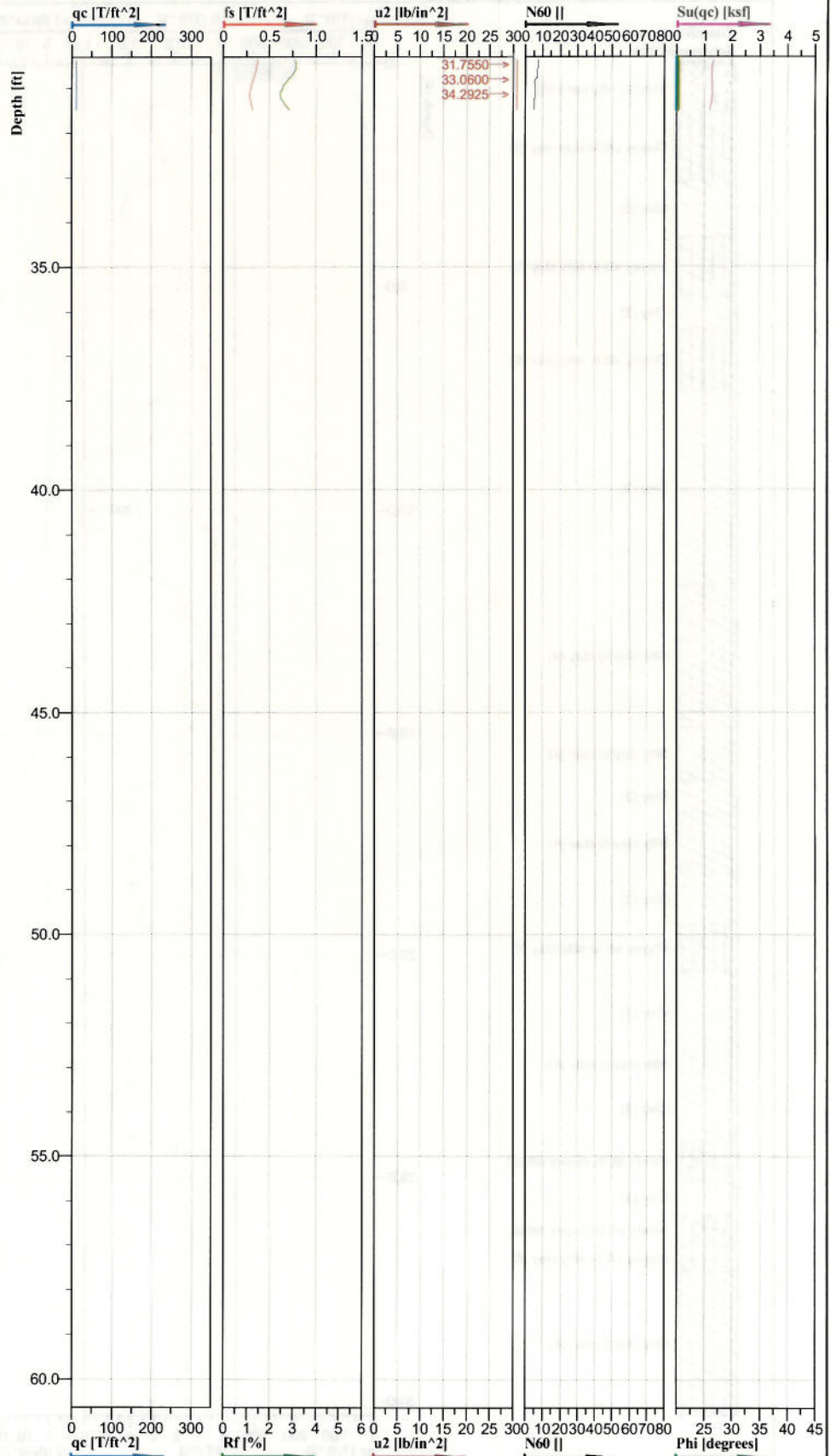
Cone No: 4274  
Tip area [cm<sup>2</sup>]: 10  
Sleeve area [cm<sup>2</sup>]: 150



Location:	Sioux Power Plant	Position:	X: 878043.41 ft, Y: 1122182.81 ft	Ground level:	443.27	Test no:	P-2
Project ID:	2010012488	Client:	Ameren Missouri	Date:	8/14/2010	Scale:	1 : 42
Project:	Ash Pond Stability Analysis			Page:	1/2	Fig:	3-2
				File:	p-2.cpd		

Classification by  
Robertson 1986

 Silty clay to clay (4)  
 Clayey silt to silty clay (5)



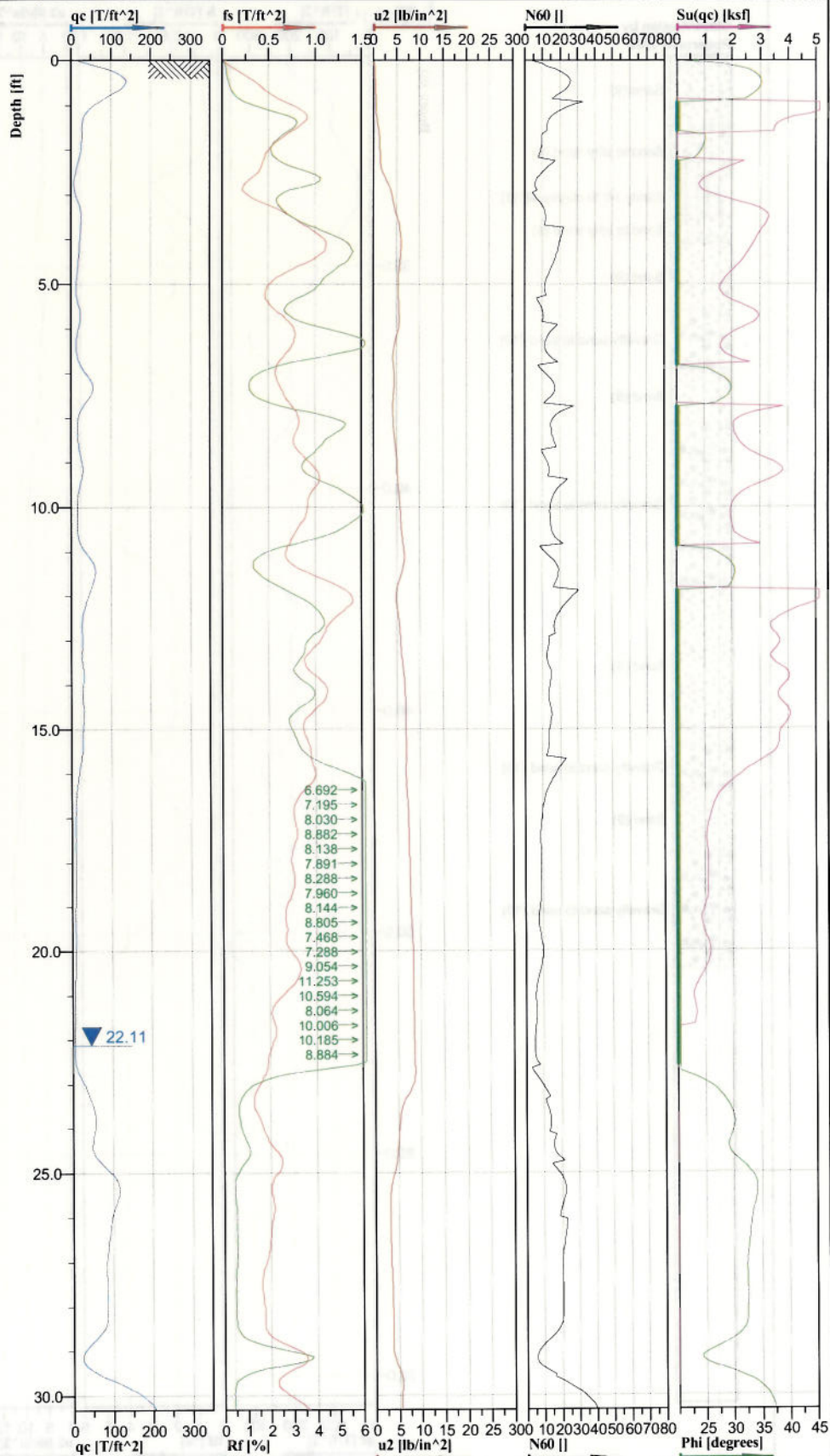
Cone No: 4274  
Tip area [cm<sup>2</sup>]: 10  
Sleeve area [cm<sup>2</sup>]: 150



Location: Sioux Power Plant	Position: X: 878043.41 ft, Y: 1122182.81 ft	Ground level: 443.27	Test no: P-2
Project ID: 2010012488	Client: Ameren Missouri	Date: 8/14/2010	Scale: 1 : 42
Project: Ash Pond Stability Analysis		Page: 2/2	Fig: 3-2
		File: p-2.cpd	

Classification by  
Robertson 1986

Sand (9)  
Clayey silt to silty clay (5)  
Sandy silt to clayey silt (6)  
Clay (3)  
Clayey silt to silty clay (5)  
Clay (3)  
Clayey silt to silty clay (5)  
Clay (3)  
Silty sand to sandy silt (7)  
Clay (3)  
Clayey silt to silty clay (5)  
Clay (3)  
Silty sand to sandy silt (7)  
Silty clay to clay (4)  
Clayey silt to silty clay (5)  
Clay (3)  
Clay (3)  
Silty sand to sandy silt (7)  
Sand to silty sand (8)  
Silty sand to sandy silt (7)  
Sand (9)  
Sand to silty sand (8)  
Sand (9)



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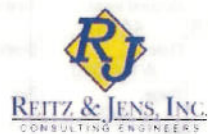
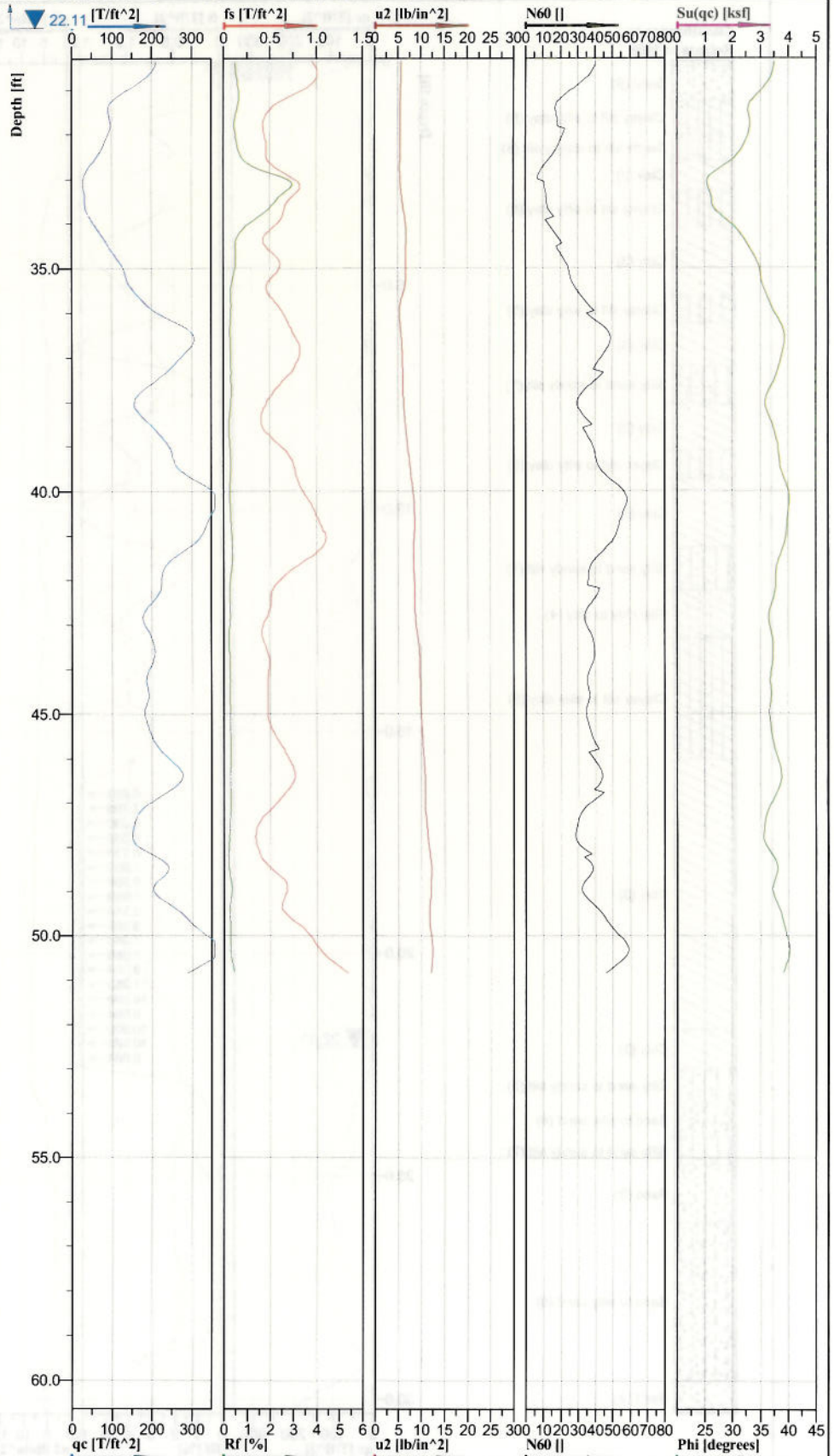
Cone No: 4274  
Tip area [cm<sup>2</sup>]: 10  
Sleeve area [cm<sup>2</sup>]: 150



Location: Sioux Power Plant	Position: X: 879085.63 ft, Y: 1119376.12 ft	Ground level: 441.47	Test no: P-3
Project ID: 2010012488	Client: Ameren Missouri	Date: 8/14/2010	Scale: 1 : 42
Project: 2010 Ash Pond Stability Analysis		Page: 1/2	Fig: 3-3
		File: p-3.cpd	

Classification by  
Robertson 1986

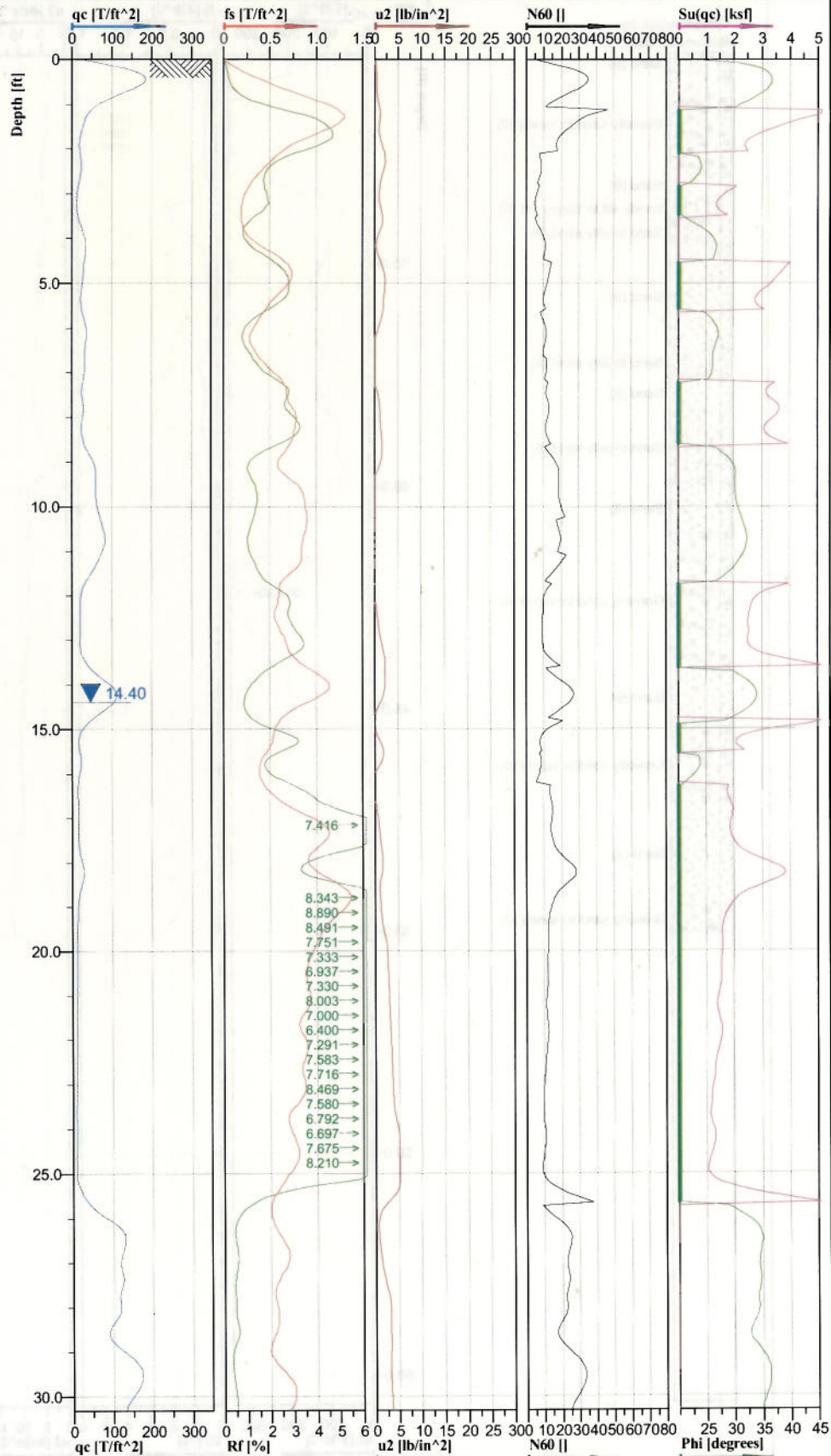
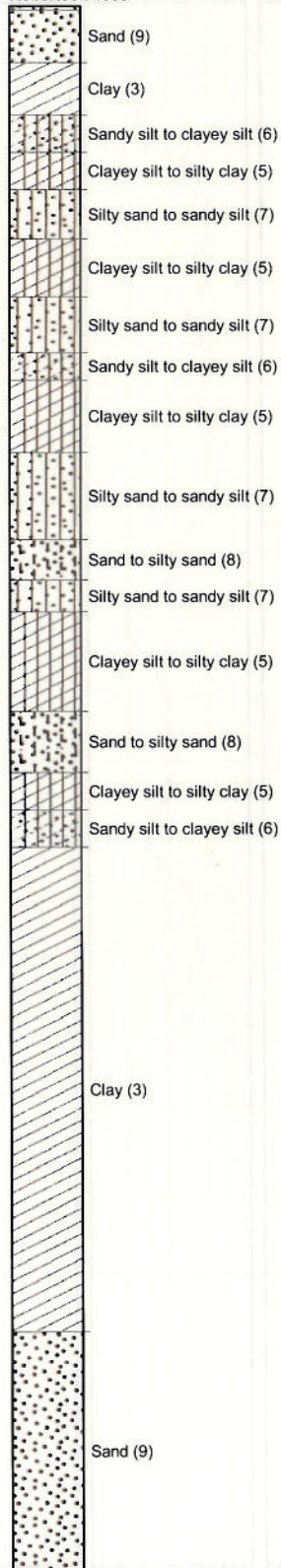
Sand (9)  
Sand to silty sand (8)  
Sandy silt to clayey silt (6)  
Sand to silty sand (8)  
Sand (9)  
Gravelly sand to sand (10)  
Sand (9)  
Gravelly sand to sand (10)  
Sand (9)  
Gravelly sand to sand (10)  
Sand (9)  
Gravelly sand to sand (10)



Cone No: 4274  
Tip area [cm2]: 10  
Sleeve area [cm2]: 150

Location: Sioux Power Plant	Position: X: 879085.63 ft, Y: 1119376.12 ft	Ground level: 441.47	Test no: P-3
Project ID: 2010012488	Client: Ameren Missouri	Date: 8/14/2010	Scale: 1 : 42
Project: 2010 Ash Pond Stability Analysis	Page: 2/2	Fig: 3-3	
		File: p-3.cpd	

Classification by  
Robertson 1986



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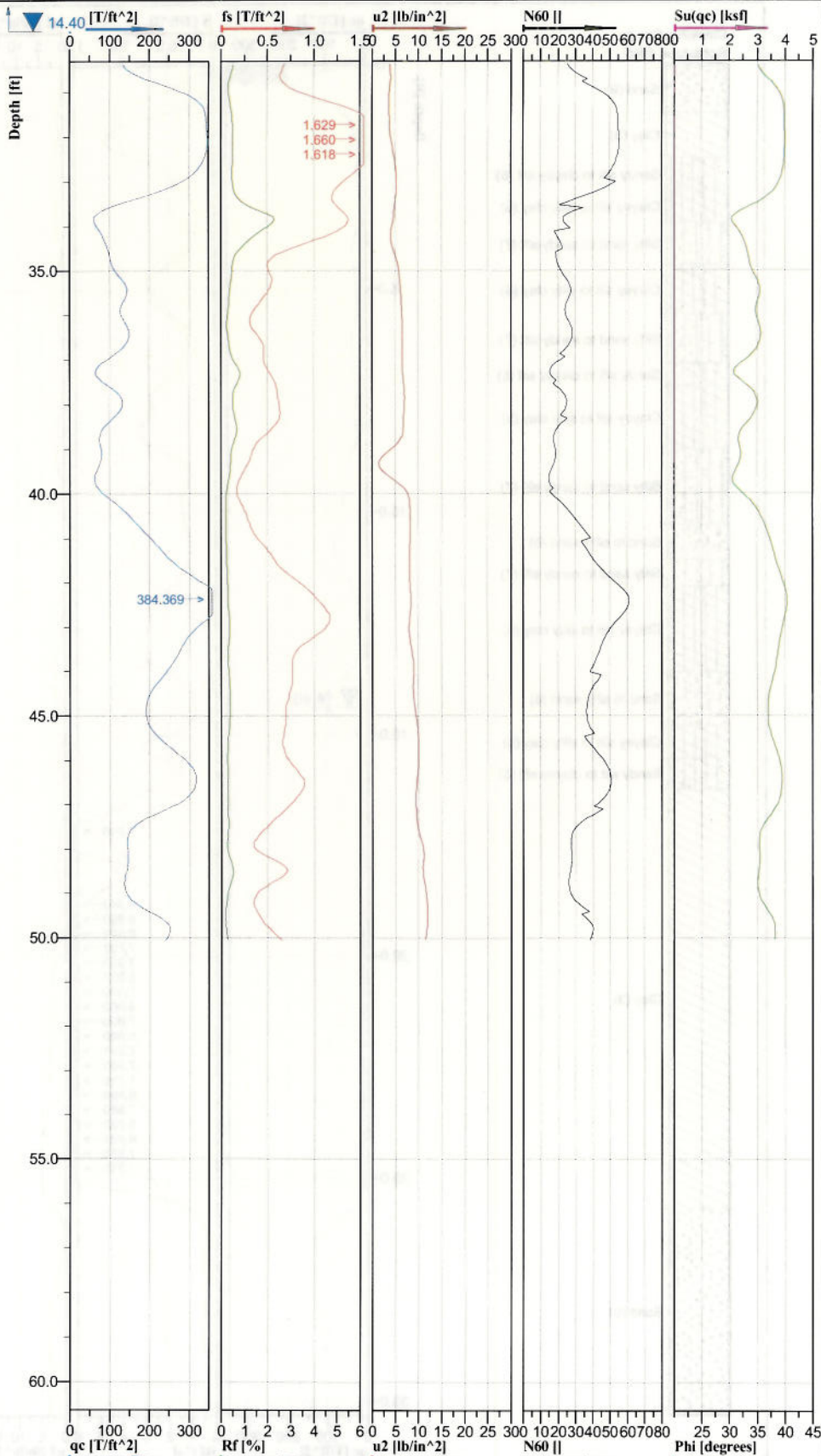
Cone No: 4274  
Tip area [cm<sup>2</sup>]: 10  
Sleeve area [cm<sup>2</sup>]: 150



Location: Sioux Power Plant	Position: X: 879812.43 ft, Y: 1119280.77 ft	Ground level: 443.08	Test no: P-4
Project ID: 2010012488	Client: Ameren Missouri	Date: 8/14/2010	Scale: 1 : 42
Project: 2010 Ash Pond Stability Analysis		Page: 1/2	Fig: 3-4
		File: p-4.cpd	

Classification by  
Robertson 1986

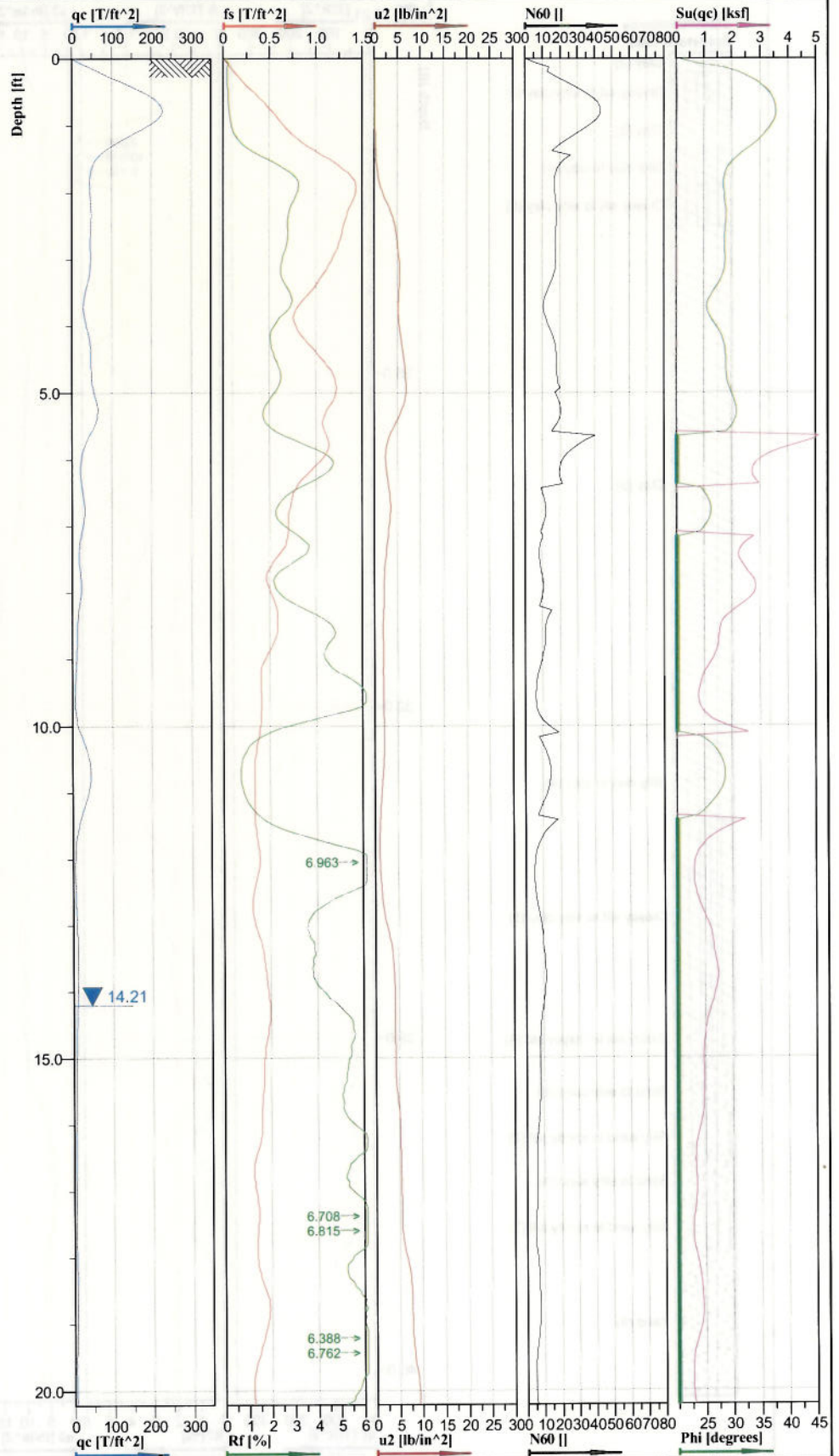
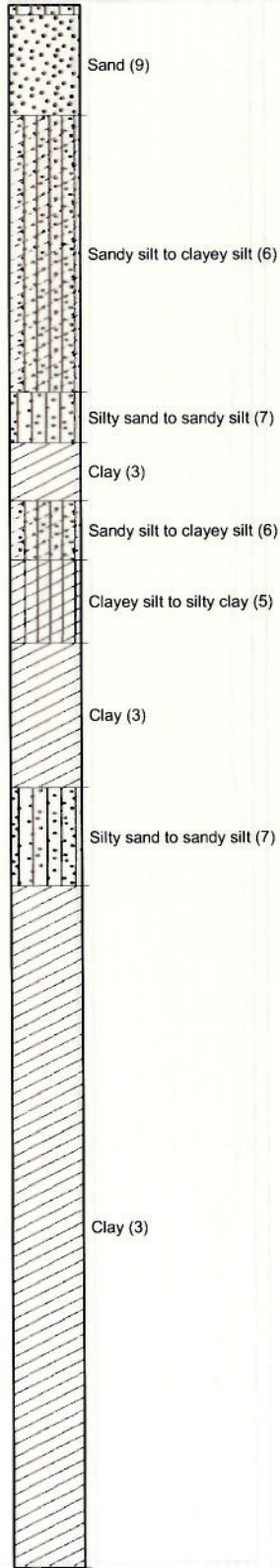
Sand (9)  
Gravelly sand to sand (10)  
Sand (9)  
Sandy silt to clayey silt (6)  
Sand to silty sand (8)  
Sand (9)  
Sand to silty sand (8)  
Sand (9)  
Sand to silty sand (8)  
Sand (9)  
Gravelly sand to sand (10)  
Sand (9)  
Gravelly sand to sand (10)  
Sand (9)  
Gravelly sand to sand (10)



Cone No: 4274  
Tip area [cm<sup>2</sup>]: 10  
Sleeve area [cm<sup>2</sup>]: 150

Location: Sioux Power Plant	Position: X: 879812.43 ft, Y: 1119280.77 ft	Ground level: 443.08	Test no: P-4
Project ID: 2010012488	Client: Ameren Missouri	Date: 8/14/2010	Scale: 1 : 42
Project: 2010 Ash Pond Stability Analysis	Page: 2/2	Fig: 3-4	
		File: p-4.cpd	

Classification by  
Robertson 1986

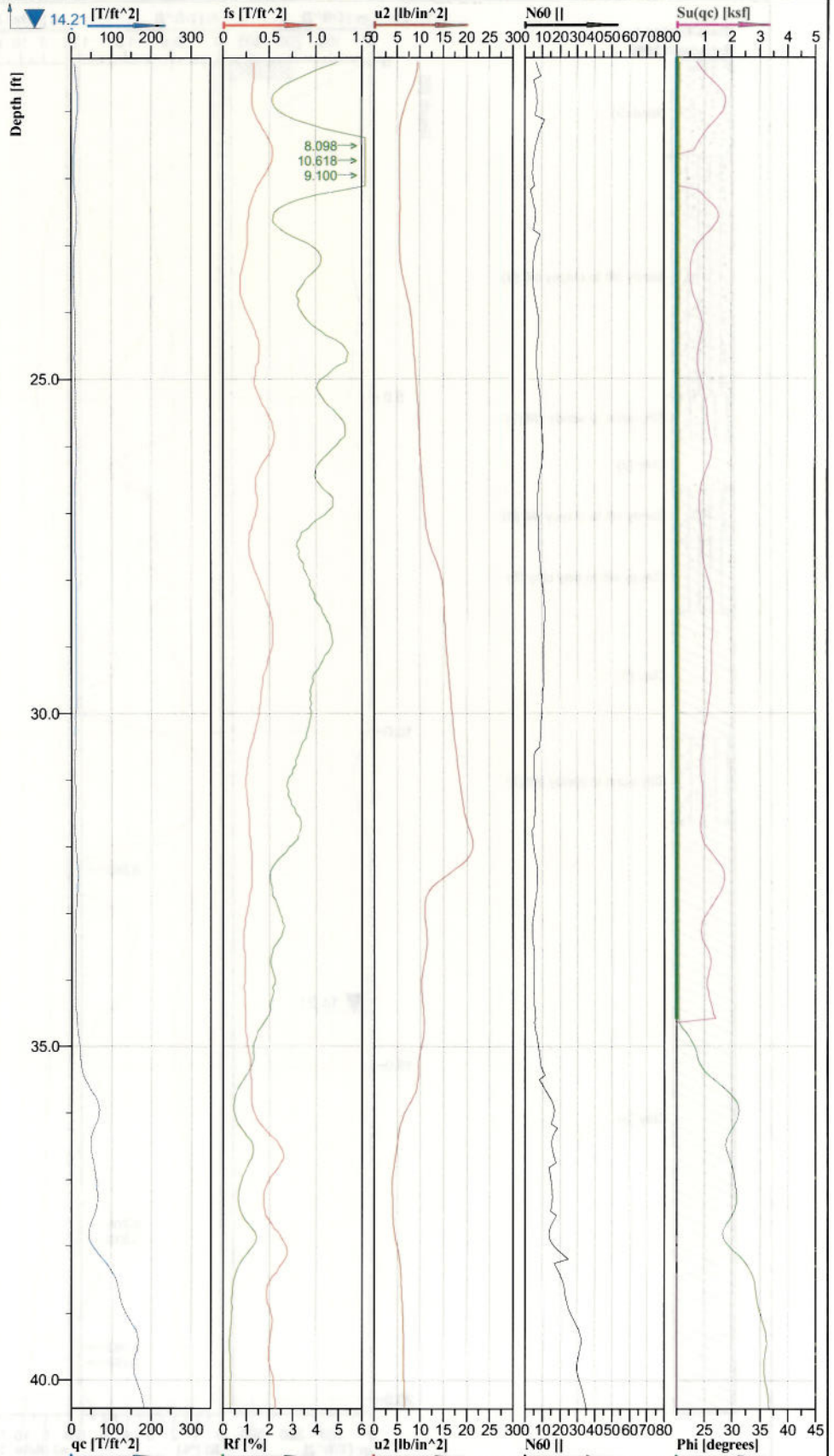
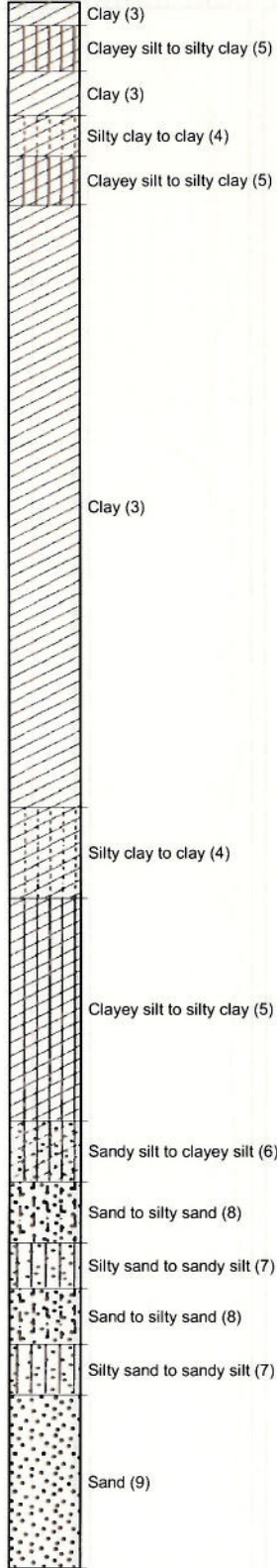


Cone No: 4274  
Tip area [cm<sup>2</sup>]: 10  
Sleeve area [cm<sup>2</sup>]: 150



Location: Sioux Power Plant	Position: X: 878362.17 ft, Y: 1122193.34 ft	Ground level: 445.77	Test no: P-8
Project ID: 2010012488	Client: Ameren Missouri	Date: 8/14/2010	Scale: 1 : 28
Project: 2010 Ash Pond Stability Analysis		Page: 1/3	Fig: 3-5
		File: p-8.cpd	

Classification by  
Robertson 1986



Cone No: 4274  
Tip area [cm<sup>2</sup>]: 10  
Sleeve area [cm<sup>2</sup>]: 150



Location: Sioux Power Plant	Position: X: 878362.17 ft, Y: 1122193.34 ft	Ground level: 445.77	Test no: P-8
Project ID: 2010012488	Client: Ameren Missouri	Date: 8/14/2010	Scale: 1 : 28
Project: 2010 Ash Pond Stability Analysis	Page: 2/3	Fig: 3-5	File: p-8.cpd

Classification by  
Robertson 1986

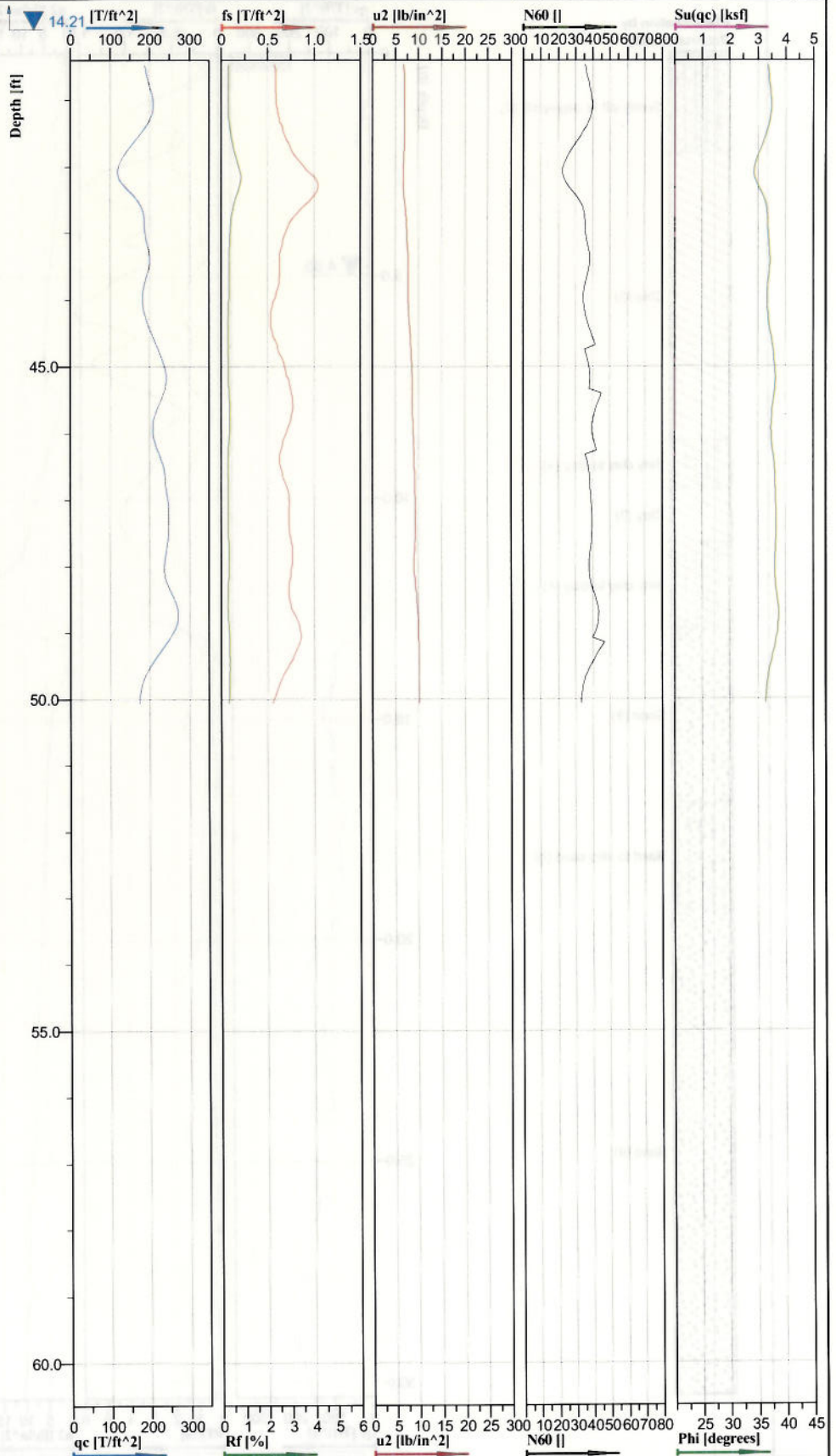
Sand (9)

Gravelly sand to sand (10)

Sand (9)

Gravelly sand to sand (10)

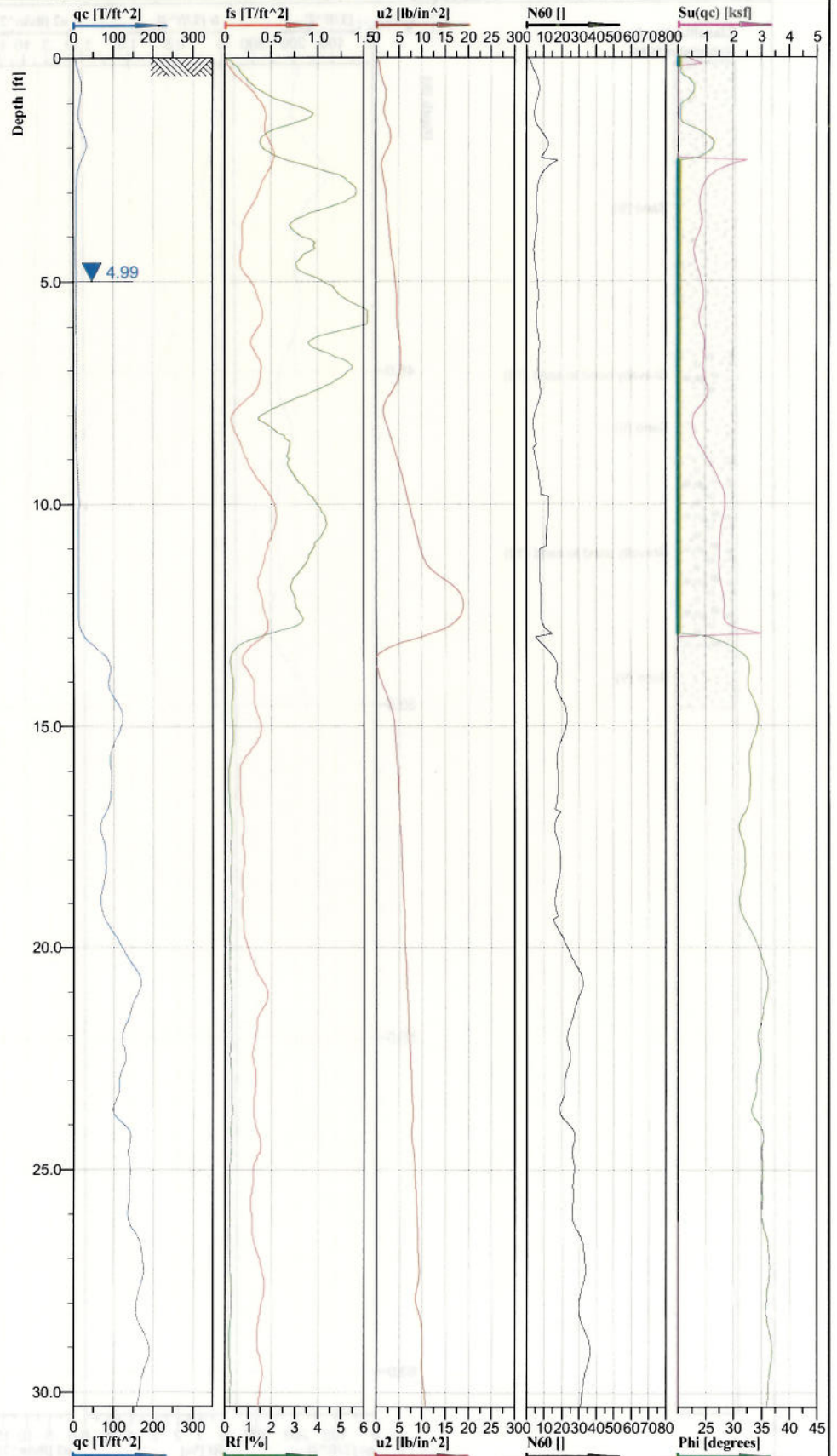
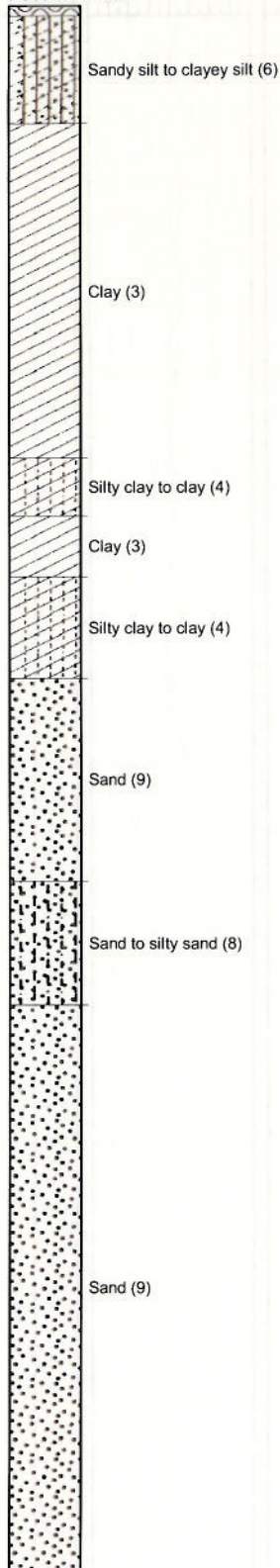
Sand (9)



Cone No: 4274  
Tip area [cm2]: 10  
Sleeve area [cm2]: 150

Location: Sioux Power Plant	Position: X: 878362.17 ft, Y: 1122193.34 ft	Ground level: 445.77	Test no: P-8
Project ID: 2010012488	Client: Ameren Missouri	Date: 8/14/2010	Scale: 1 : 28
Project: 2010 Ash Pond Stability Analysis	Page: 3/3	Fig: 3-5	
	File: p-8.cpd		

Classification by  
Robertson 1986

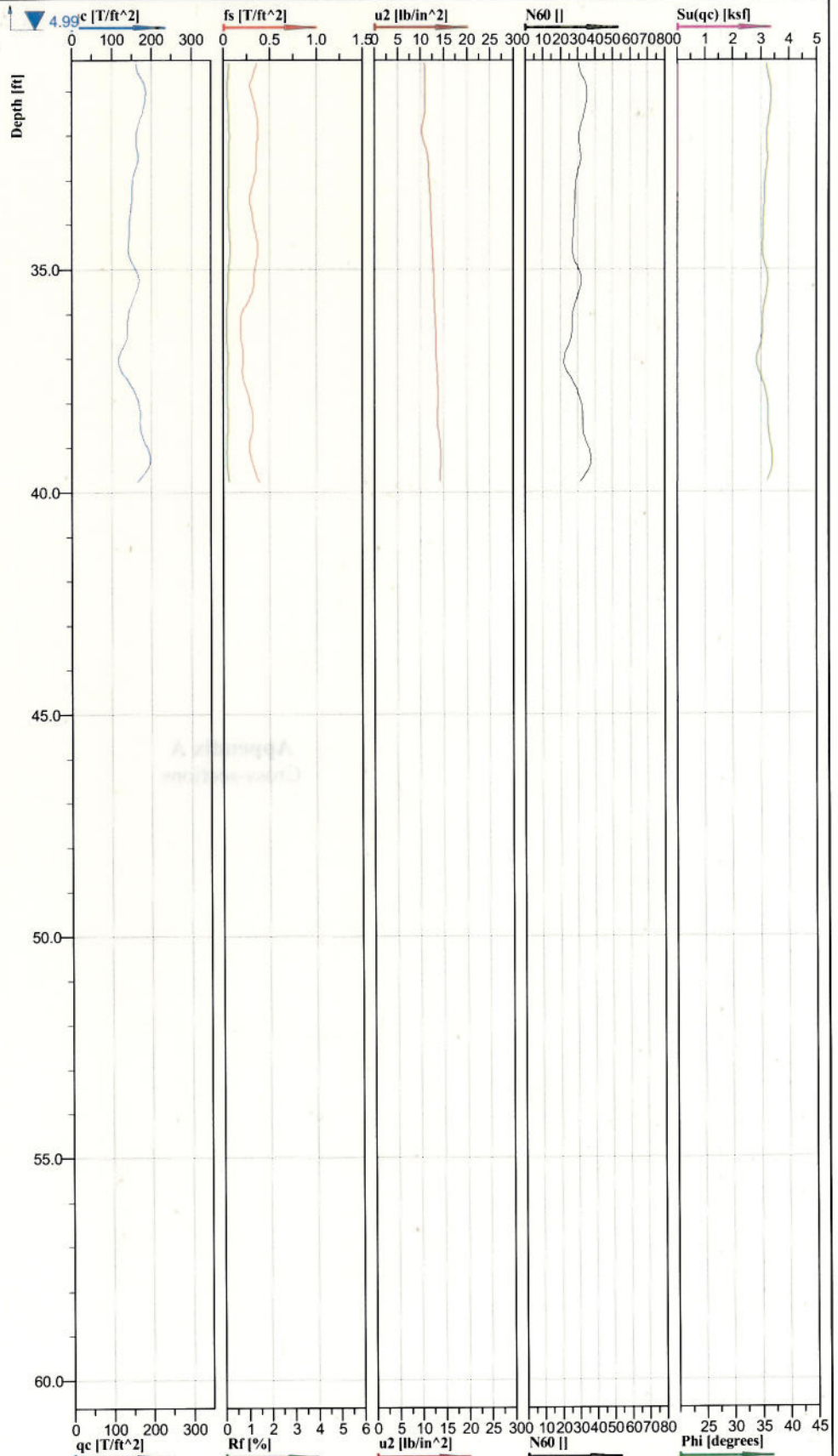


Location: Sioux Power Plant	Position: X: 878082.28 ft, Y: 1122220.67 ft	Ground level: 425.79	Test no: P-9
Project ID: 2010012488	Client: Ameren Missouri	Date: 8/14/2010	Scale: 1 : 42
Project: 2010 Ash Pond Stability Analysis		Page: 1/2	Fig: 3-6
		File: p-9.cpd	

Classification by  
Robertson 1986



Sand (9)



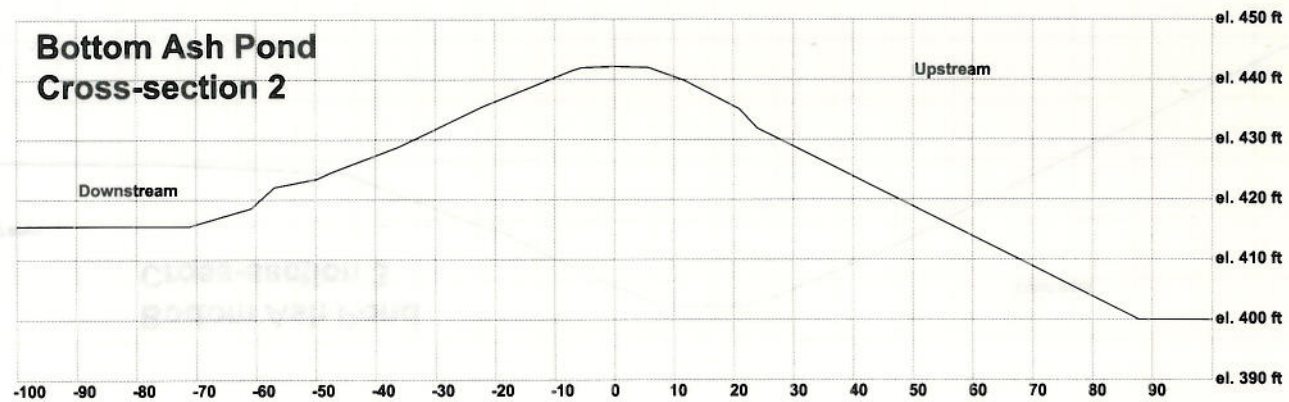
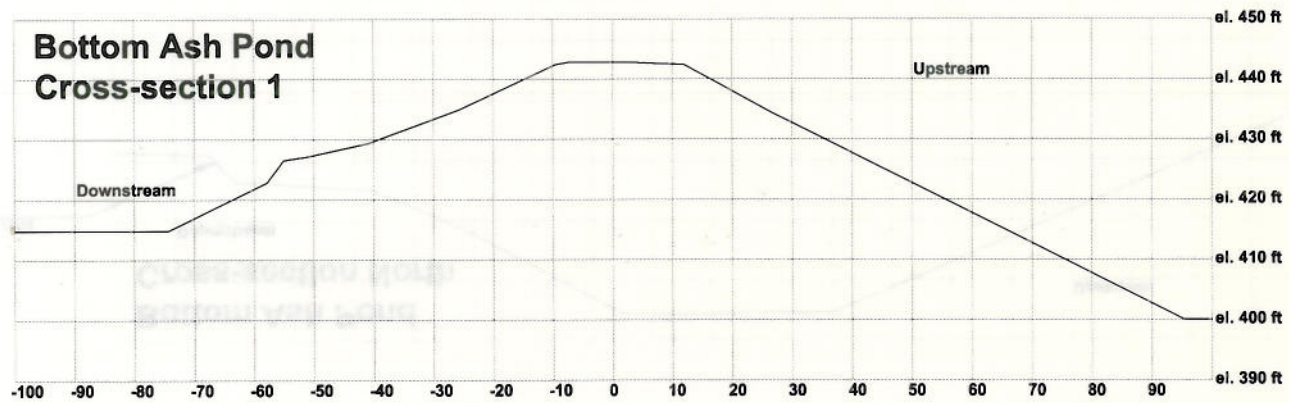
Cone No: 4274  
Tip area [cm<sup>2</sup>]: 10  
Sleeve area [cm<sup>2</sup>]: 150



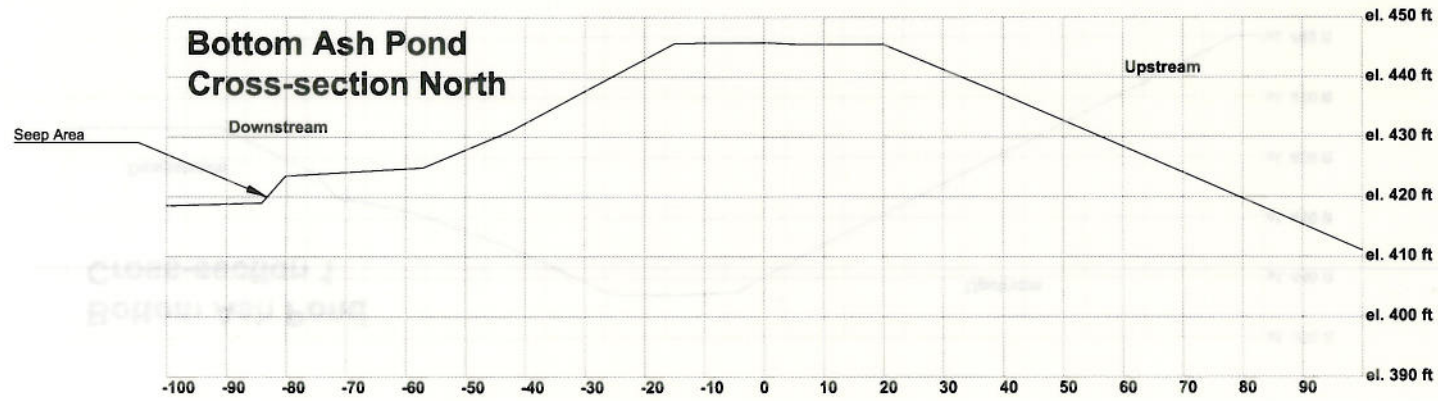
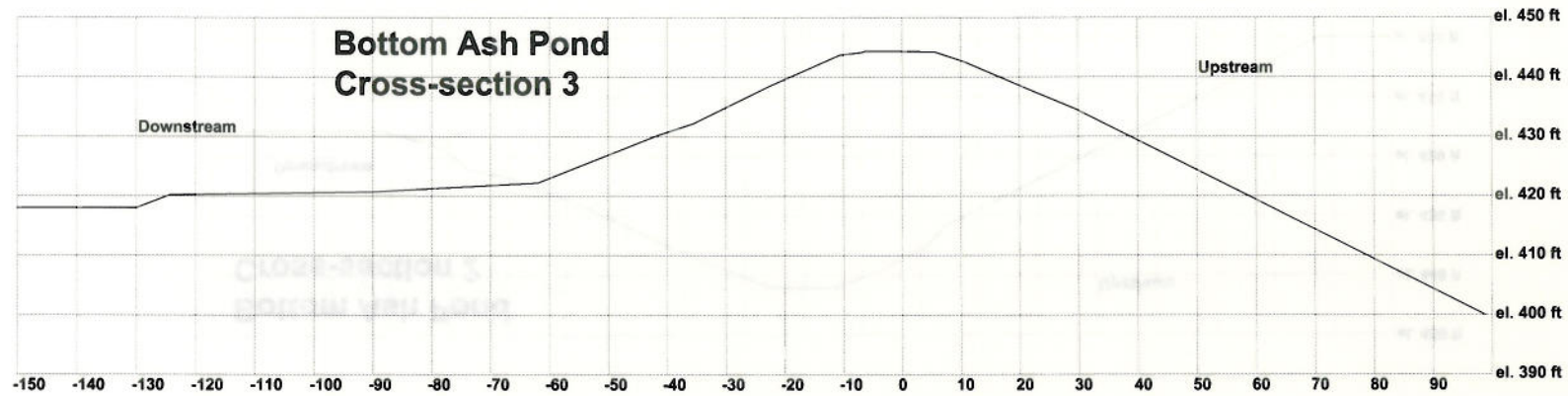
Location: Sioux Power Plant	Position: X: 878082.28 ft, Y: 1122220.67 ft	Ground level: 425.79	Test no: P-9
Project ID: 2010012488	Client: Ameren Missouri	Date: 8/14/2010	Scale: 1 : 42
Project: 2010 Ash Pond Stability Analysis	Page: 2/2	Fig: 3-6	
		File: p-9.cpd	



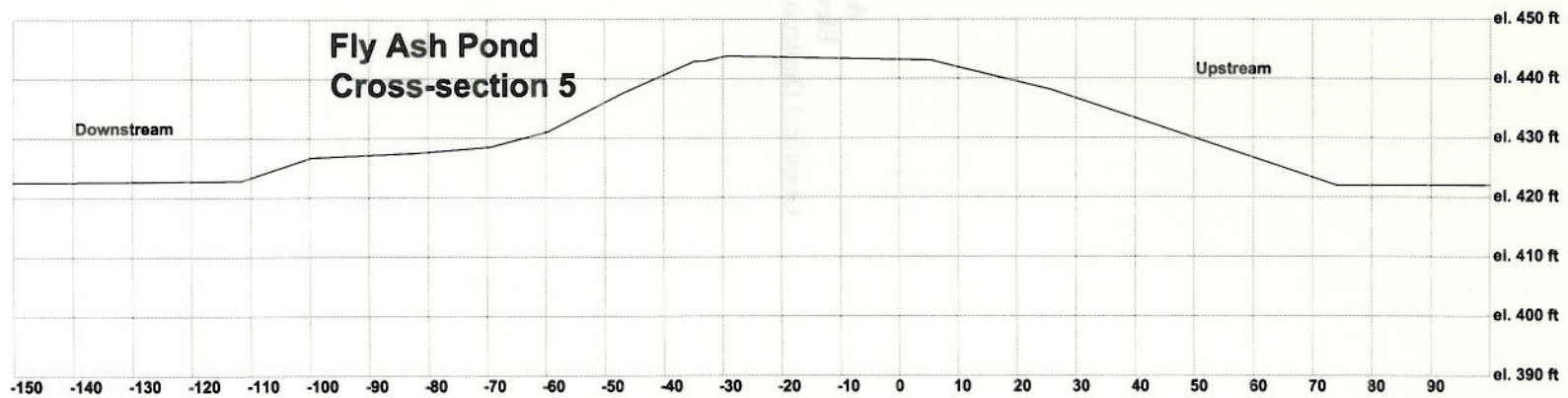
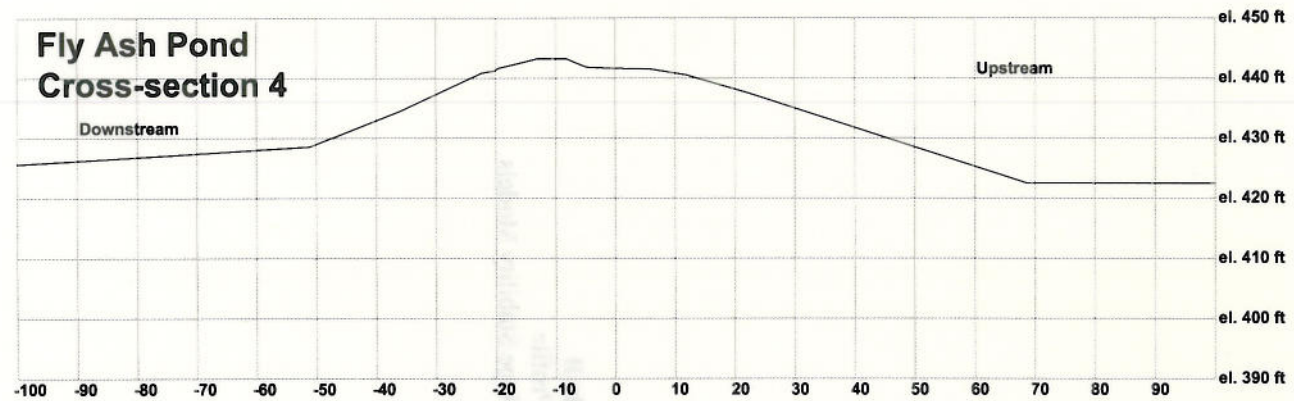
# Sioux Power Station



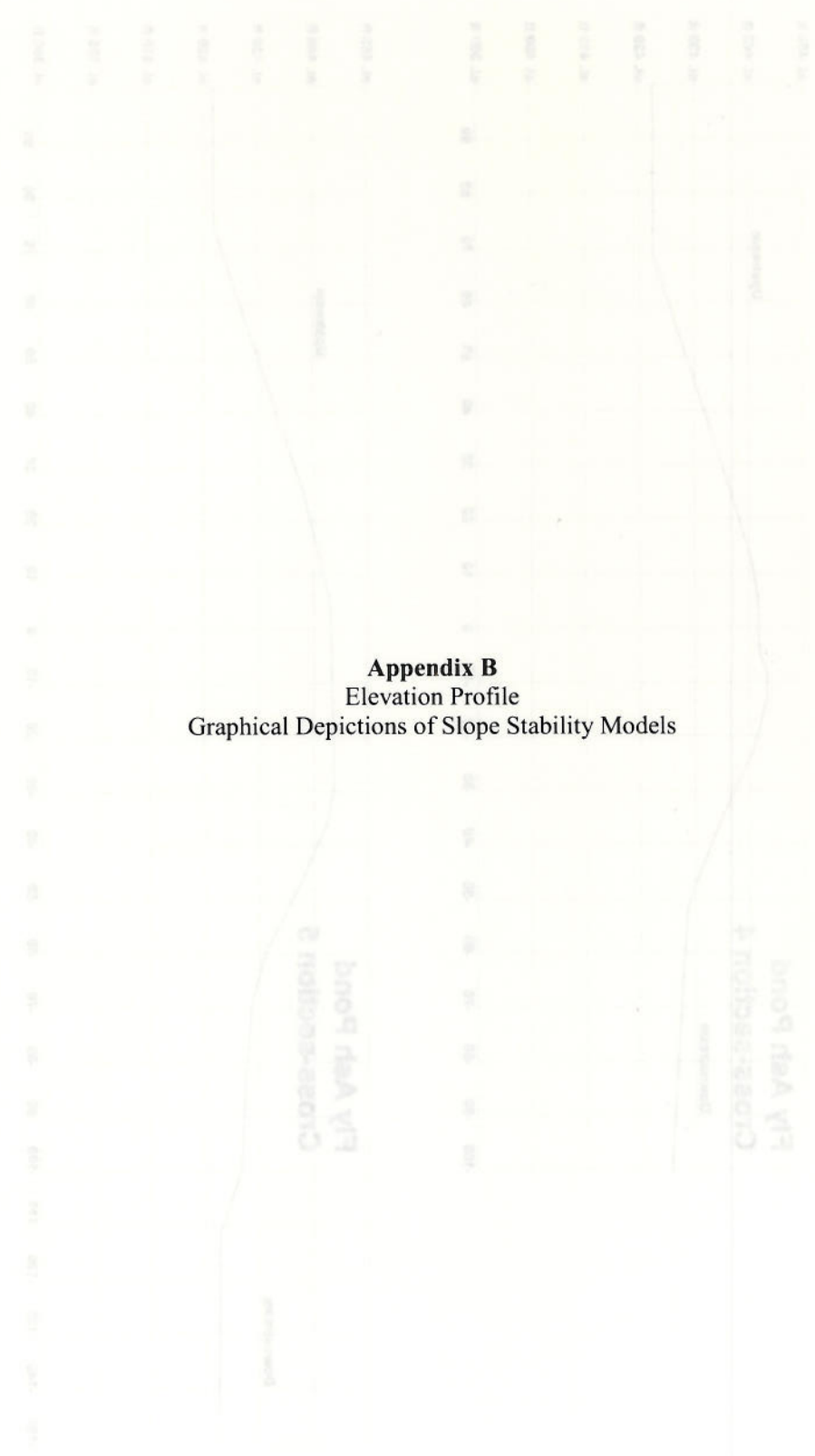
# Sioux Power Station



# Sioux Power Station



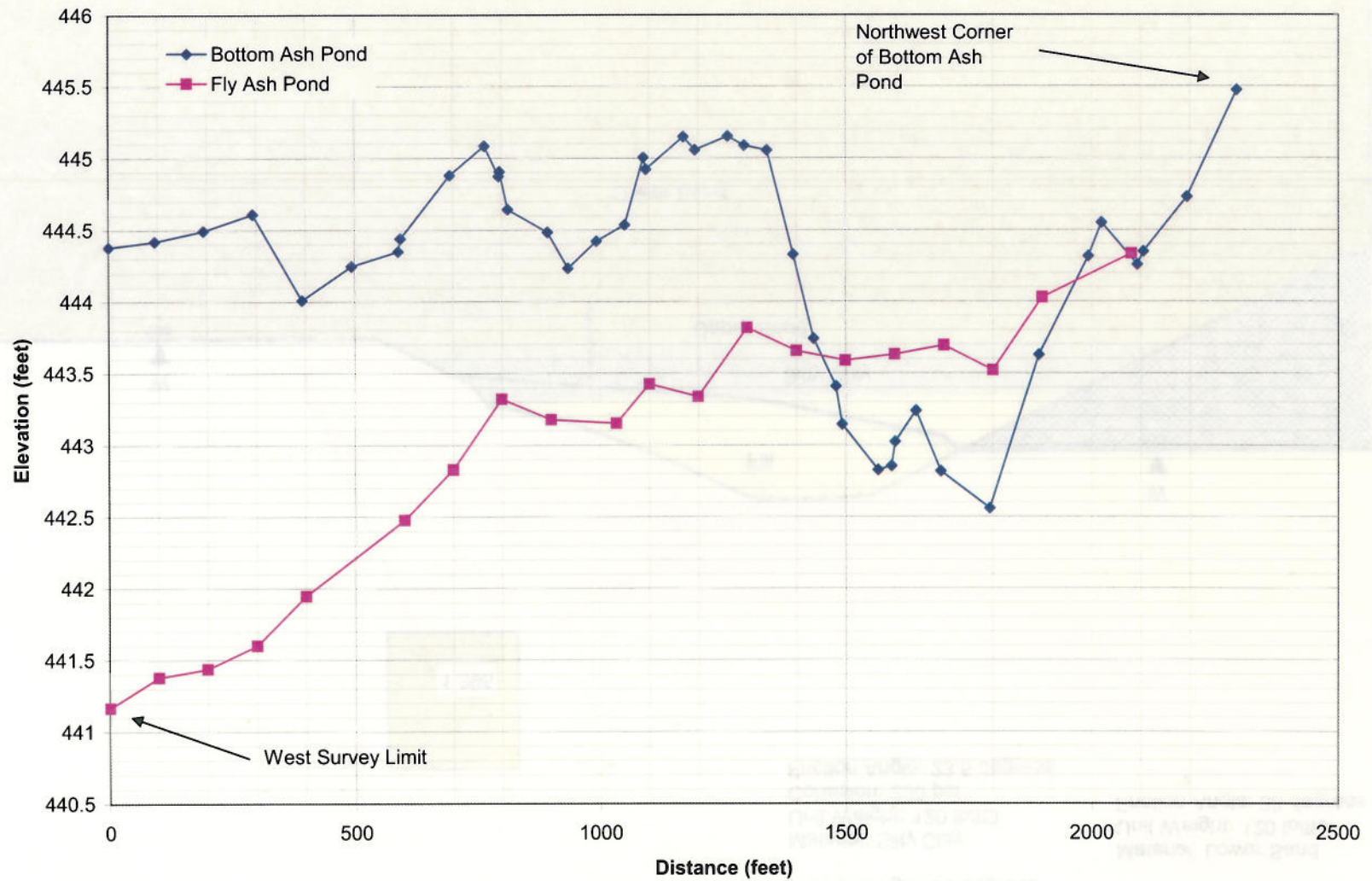
10/1/02  
 10/1/02  
 10/1/02



**Appendix B**  
 Elevation Profile  
 Graphical Depictions of Slope Stability Models

10/1/02  
 10/1/02  
 10/1/02

# Sioux Power Station Elevation Profile



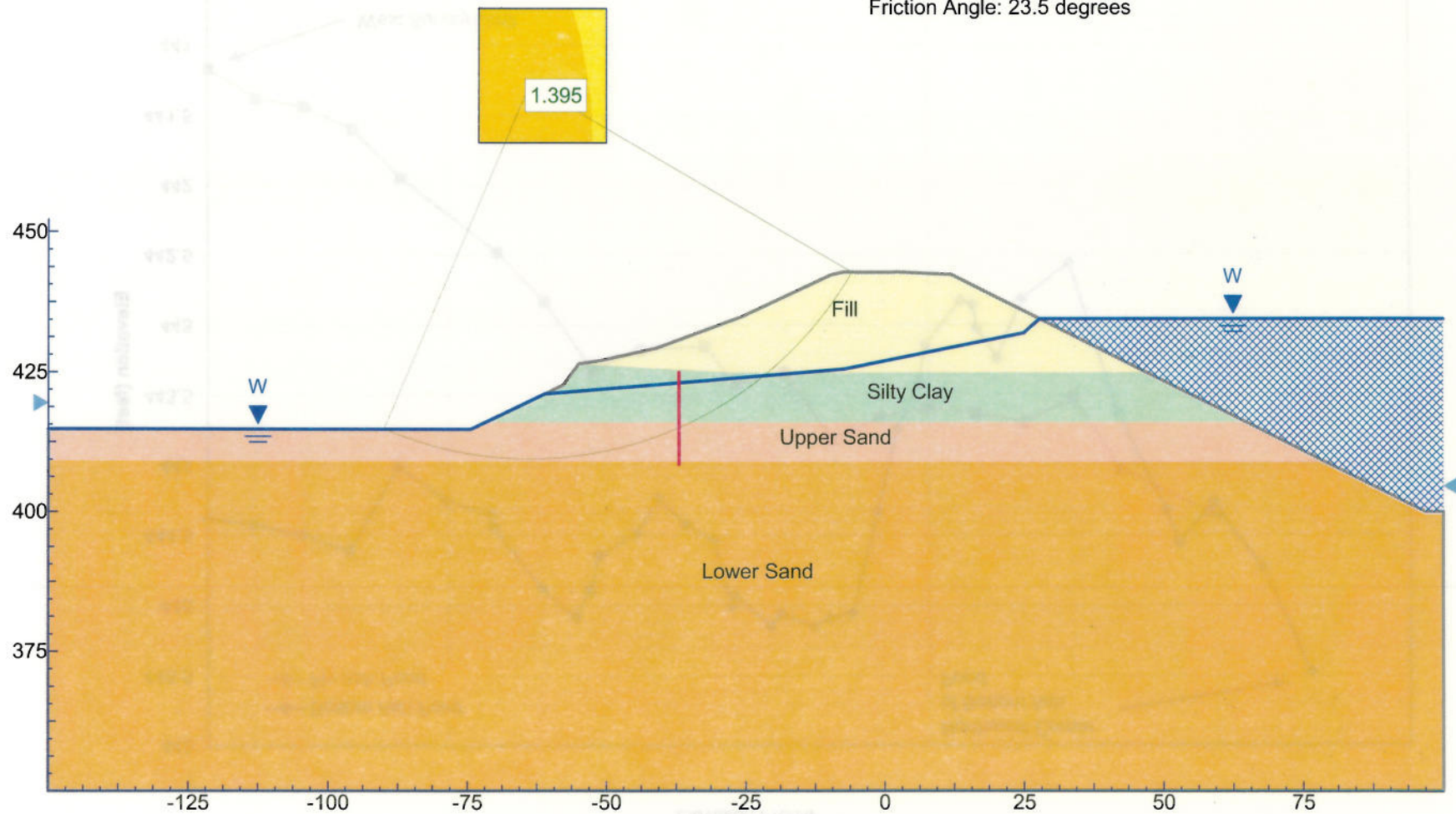
Sioux Power Station  
Steady Seepage, Full Reservoir  
Cross-section 1

Material: Fill  
Unit Weight: 120 lb/ft<sup>3</sup>  
Cohesion: 100 psf  
Friction Angle: 26 degrees

Material: Upper Sand  
Unit Weight: 120 lb/ft<sup>3</sup>  
Friction Angle: 30 degrees

Material: Silty Clay  
Unit Weight: 120 lb/ft<sup>3</sup>  
Cohesion: 350 psf  
Friction Angle: 23.5 degrees

Material: Lower Sand  
Unit Weight: 120 lb/ft<sup>3</sup>  
Friction Angle: 33 degrees



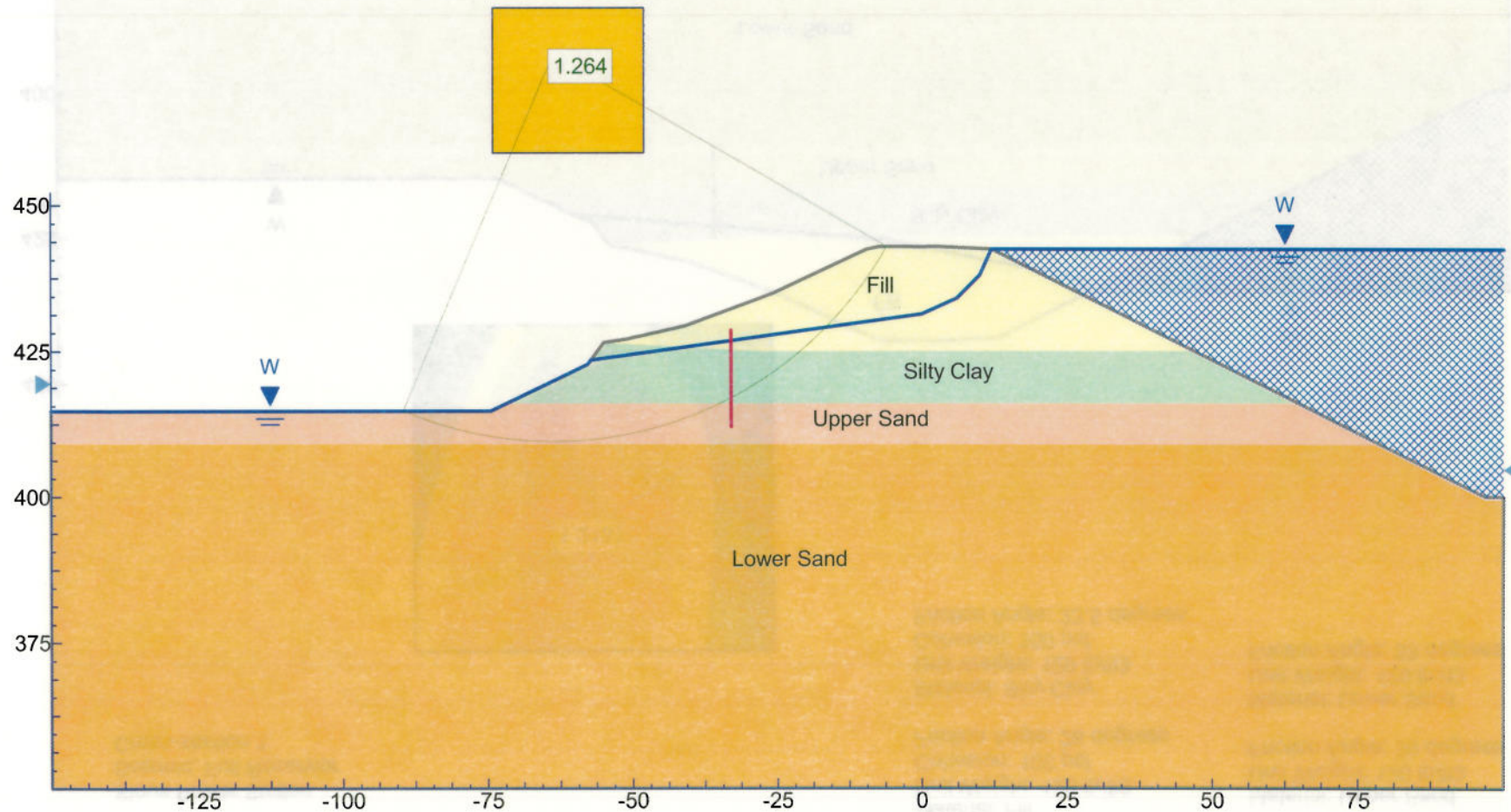
Sioux Power Station  
Steady Seepage, Maximum Reservoir  
Cross-section 1

Material: Fill  
Unit Weight: 120 lb/ft<sup>3</sup>  
Cohesion: 100 psf  
Friction Angle: 26 degrees

Material: Silty Clay  
Unit Weight: 120 lb/ft<sup>3</sup>  
Cohesion: 350 psf  
Friction Angle: 23.5 degrees

Material: Upper Sand  
Unit Weight: 120 lb/ft<sup>3</sup>  
Friction Angle: 30 degrees

Material: Lower Sand  
Unit Weight: 120 lb/ft<sup>3</sup>  
Friction Angle: 33 degrees



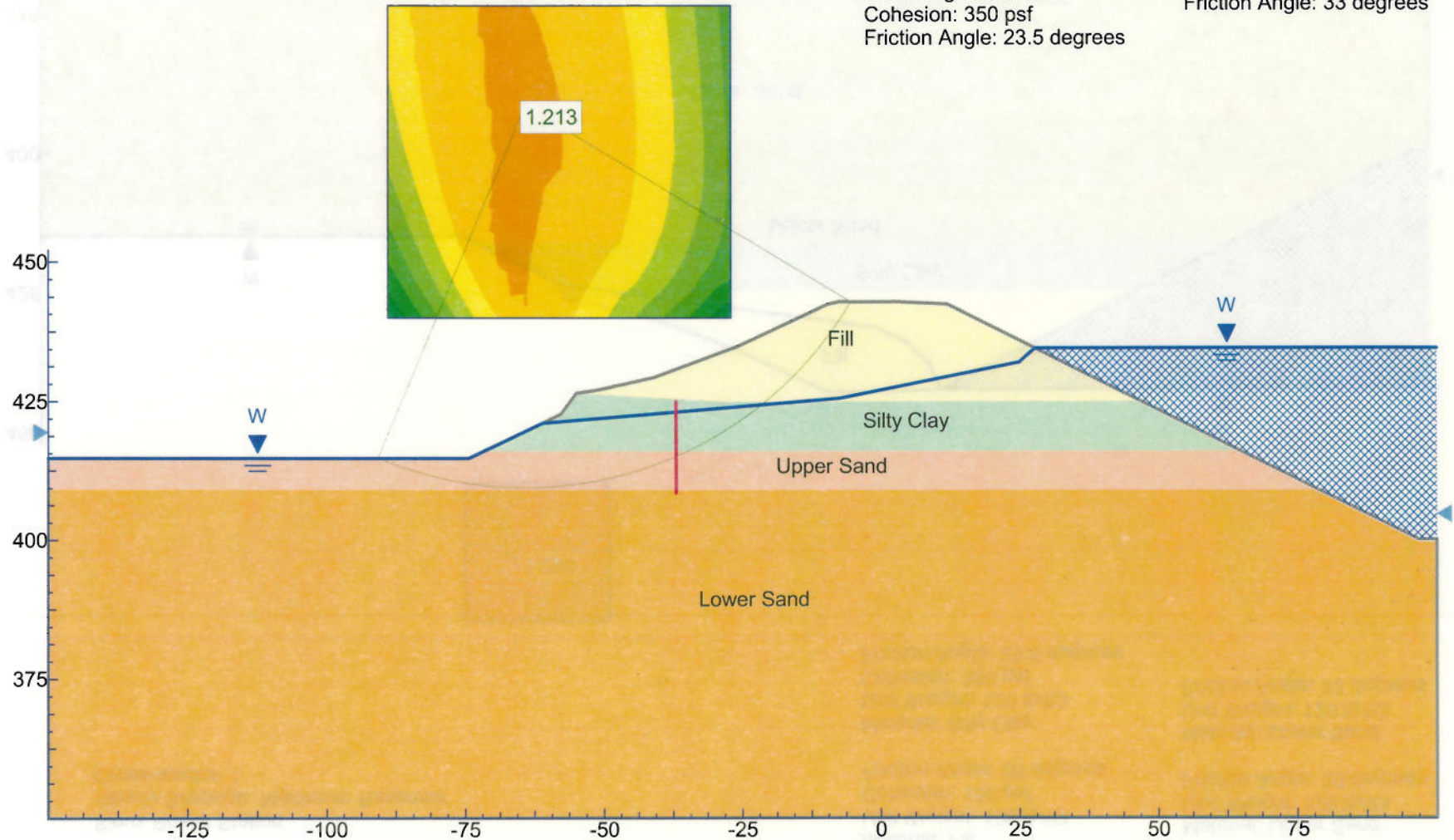
Sioux Power Station  
Seismic, Full Reservoir  
Cross-section 1

Material: Fill  
Unit Weight: 120 lb/ft<sup>3</sup>  
Cohesion: 100 psf  
Friction Angle: 26 degrees

Material: Silty Clay  
Unit Weight: 120 lb/ft<sup>3</sup>  
Cohesion: 350 psf  
Friction Angle: 23.5 degrees

Material: Upper Sand  
Unit Weight: 120 lb/ft<sup>3</sup>  
Friction Angle: 30 degrees

Material: Lower Sand  
Unit Weight: 120 lb/ft<sup>3</sup>  
Friction Angle: 33 degrees



Sioux Power Station  
Steady Seepage, Full Reservoir  
Cross-section 5

Material: Upper Fill  
Unit Weight: 120 lb/ft<sup>3</sup>  
Friction Angle: 25 degrees

Material: Silty Sand  
Unit Weight: 120 lb/ft<sup>3</sup>  
Friction Angle: 27.5 degrees

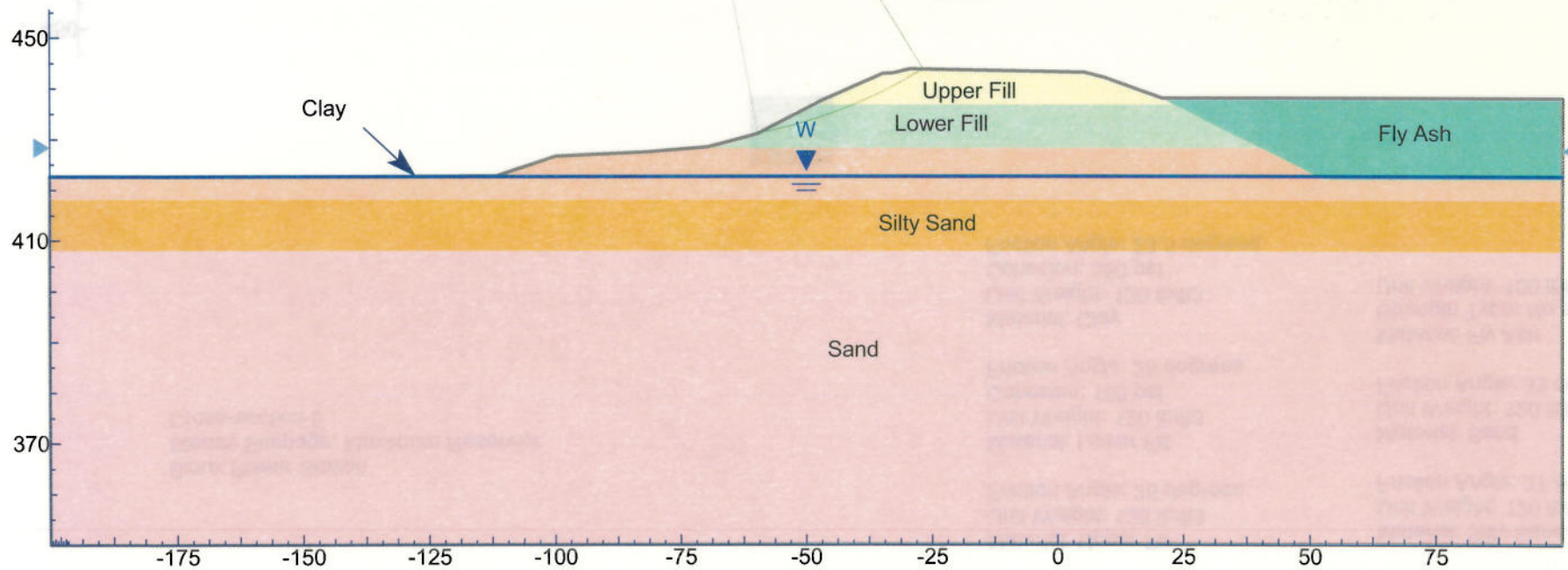
Material: Lower Fill  
Unit Weight: 120 lb/ft<sup>3</sup>  
Cohesion: 100 psf  
Friction Angle: 28 degrees

Material: Sand  
Unit Weight: 120 lb/ft<sup>3</sup>  
Friction Angle: 33 degrees

Material: Clay  
Unit Weight: 120 lb/ft<sup>3</sup>  
Cohesion: 350 psf  
Friction Angle: 23.5 degrees

Material: Fly Ash  
Strength Type: No strength  
Unit Weight: 100 lb/ft<sup>3</sup>

1.864



Sioux Power Station  
Steady Seepage, Maximum Reservoir  
Cross-section 5

Material: Upper Fill  
Unit Weight: 120 lb/ft<sup>3</sup>  
Friction Angle: 25 degrees

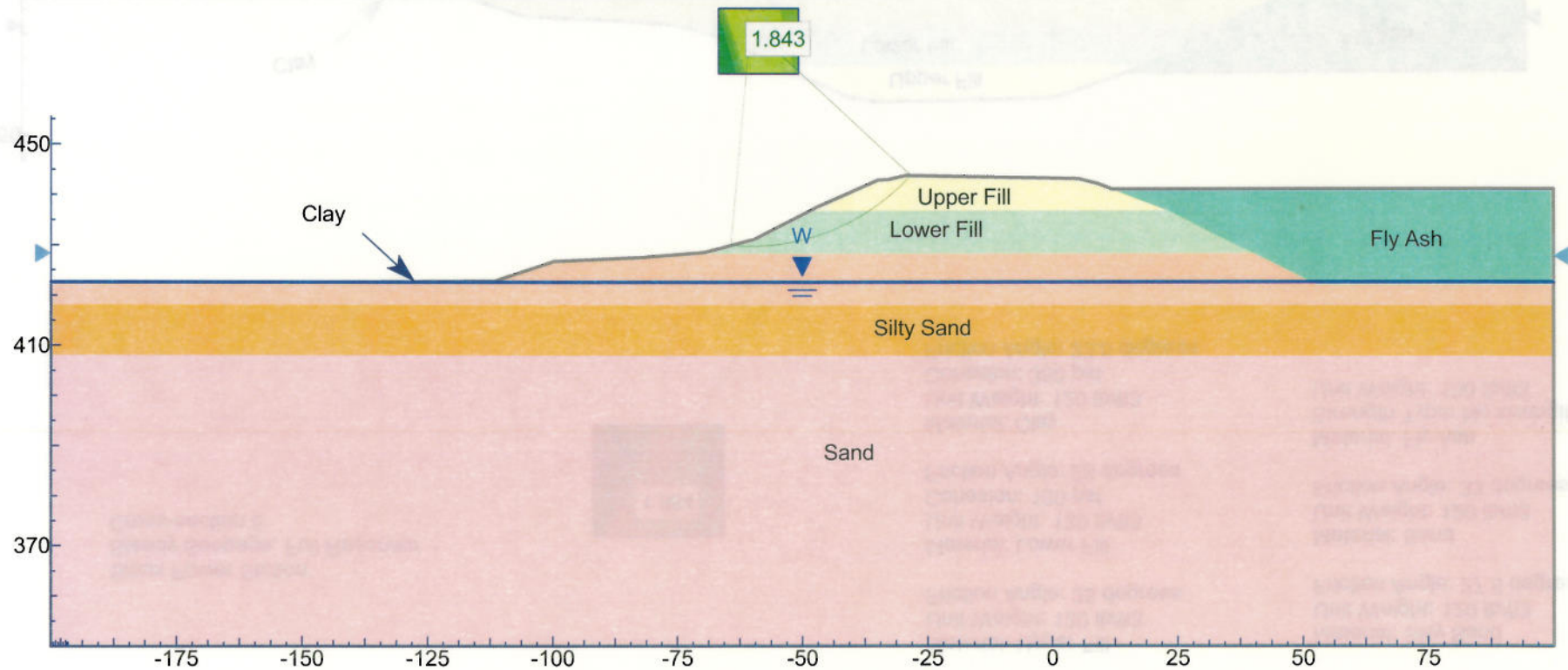
Material: Silty Sand  
Unit Weight: 120 lb/ft<sup>3</sup>  
Friction Angle: 27.5 degrees

Material: Lower Fill  
Unit Weight: 120 lb/ft<sup>3</sup>  
Cohesion: 100 psf  
Friction Angle: 28 degrees

Material: Sand  
Unit Weight: 120 lb/ft<sup>3</sup>  
Friction Angle: 33 degrees

Material: Clay  
Unit Weight: 120 lb/ft<sup>3</sup>  
Cohesion: 350 psf  
Friction Angle: 23.5 degrees

Material: Fly Ash  
Strength Type: No strength  
Unit Weight: 100 lb/ft<sup>3</sup>



Sioux Power Station  
Seismic, Full Reservoir  
Cross-section 5

Material: Upper Fill  
Unit Weight: 120 lb/ft<sup>3</sup>  
Friction Angle: 25 degrees

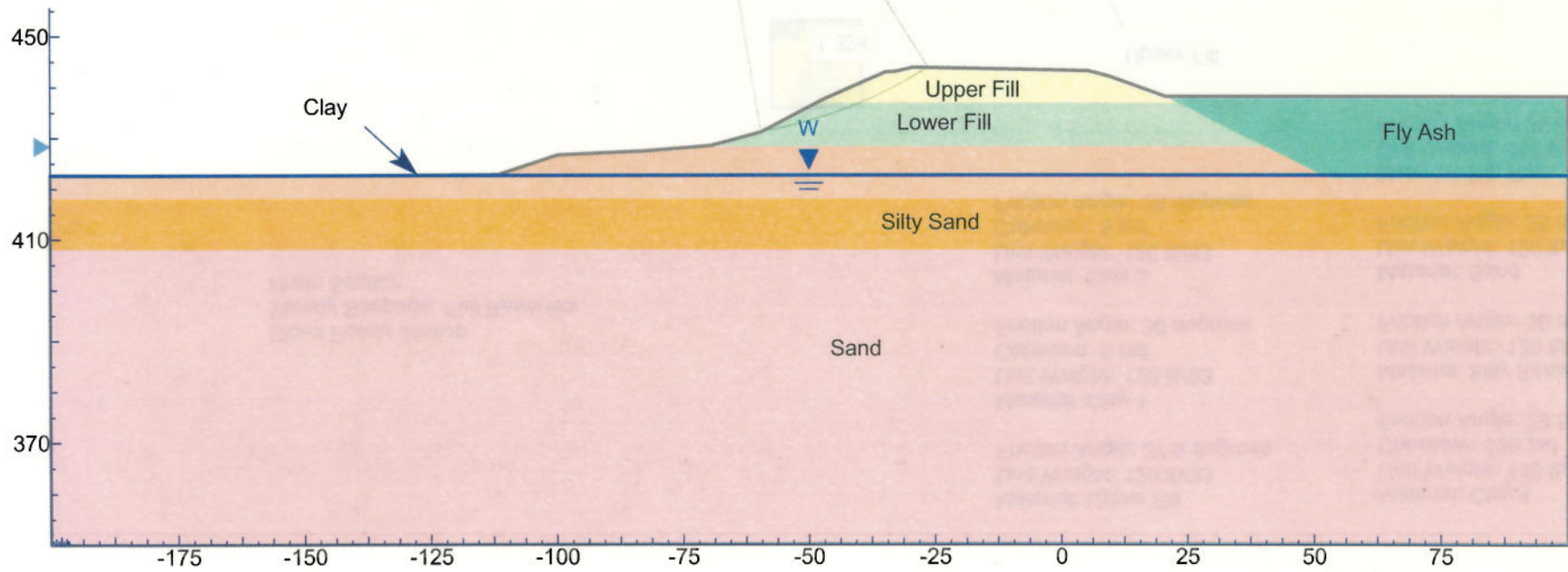
Material: Silty Sand  
Unit Weight: 120 lb/ft<sup>3</sup>  
Friction Angle: 27.5 degrees

Material: Lower Fill  
Unit Weight: 120 lb/ft<sup>3</sup>  
Cohesion: 100 psf  
Friction Angle: 28 degrees

Material: Sand  
Unit Weight: 120 lb/ft<sup>3</sup>  
Friction Angle: 33 degrees

Material: Clay  
Unit Weight: 120 lb/ft<sup>3</sup>  
Cohesion: 350 psf  
Friction Angle: 23.5 degrees

Material: Fly Ash  
Strength Type: No strength  
Unit Weight: 100 lb/ft<sup>3</sup>



Sioux Power Station  
Steady Seepage, Full Reservoir  
North Section

Material: Upper Fill  
Unit Weight: 120 lb/ft<sup>3</sup>  
Friction Angle: 27.5 degrees

Material: Clay 1  
Unit Weight: 120 lb/ft<sup>3</sup>  
Cohesion: 5 psf  
Friction Angle: 30 degrees

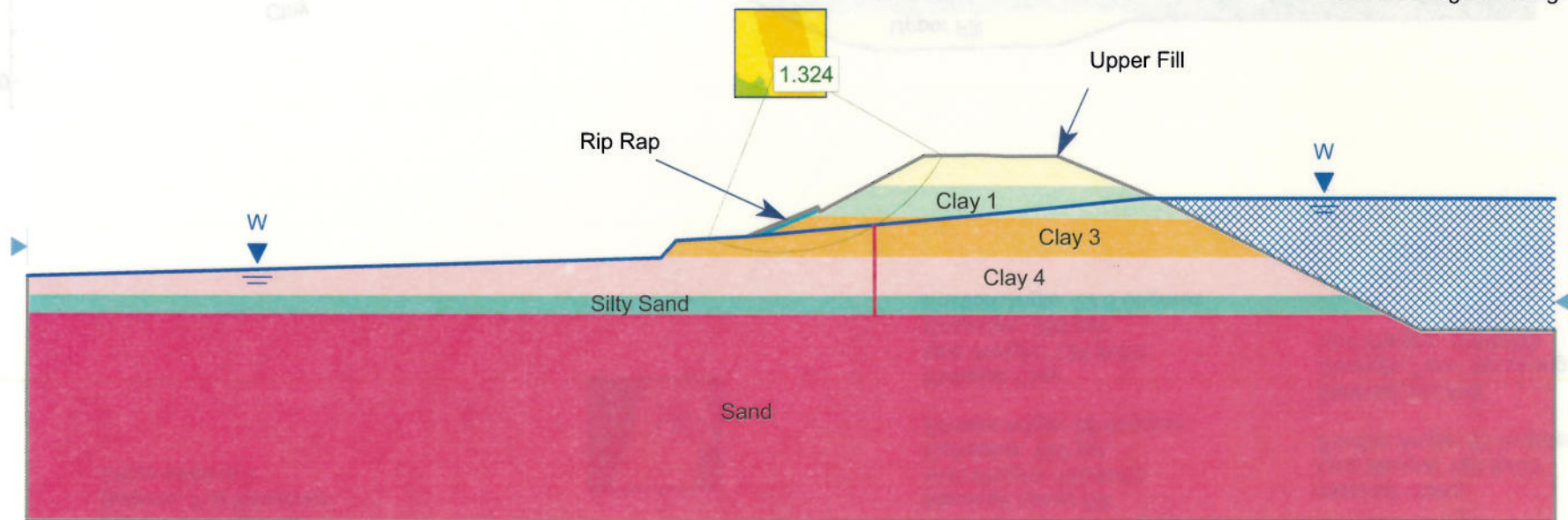
Material: Clay 3  
Unit Weight: 120 lb/ft<sup>3</sup>  
Cohesion: 5 psf  
Friction Angle: 28 degrees

Material: Clay 4  
Unit Weight: 120 lb/ft<sup>3</sup>  
Cohesion: 350 psf  
Friction Angle: 23.5 degrees

Material: Silty Sand  
Unit Weight: 120 lb/ft<sup>3</sup>  
Friction Angle: 30 degrees

Material: Sand  
Unit Weight: 120 lb/ft<sup>3</sup>  
Friction Angle: 35 degrees

Material: Rip Rap  
Unit Weight: 110 lb/ft<sup>3</sup>  
Friction Angle: 35 degrees



Sioux Power Station  
Seismic, Full Reservoir  
North Section

Material: Upper Fill  
Unit Weight: 120 lb/ft<sup>3</sup>  
Friction Angle: 27.5 degrees

Material: Clay 1  
Unit Weight: 120 lb/ft<sup>3</sup>  
Cohesion: 5 psf  
Friction Angle: 30 degrees

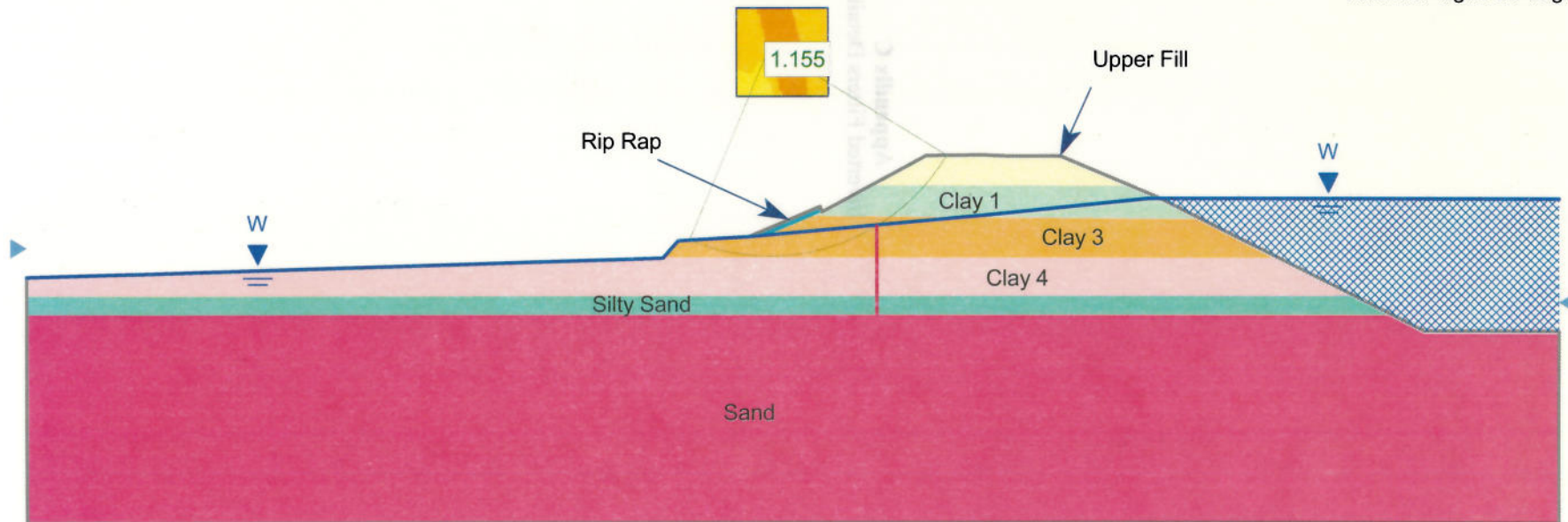
Material: Clay 3  
Unit Weight: 120 lb/ft<sup>3</sup>  
Cohesion: 5 psf  
Friction Angle: 28 degrees

Material: Clay 4  
Unit Weight: 120 lb/ft<sup>3</sup>  
Cohesion: 350 psf  
Friction Angle: 23.5 degrees

Material: Silty Sand  
Unit Weight: 120 lb/ft<sup>3</sup>  
Friction Angle: 30 degrees

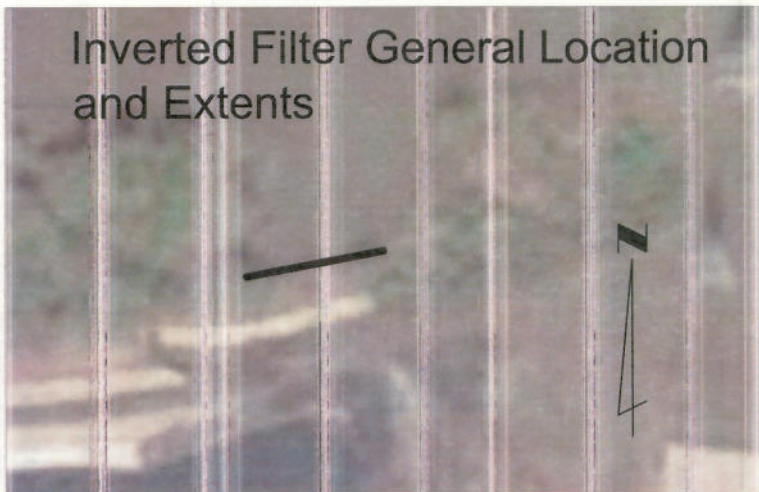
Material: Sand  
Unit Weight: 120 lb/ft<sup>3</sup>  
Friction Angle: 35 degrees

Material: Rip Rap  
Unit Weight: 110 lb/ft<sup>3</sup>  
Friction Angle: 35 degrees





## Inverted Filter General Location and Extents

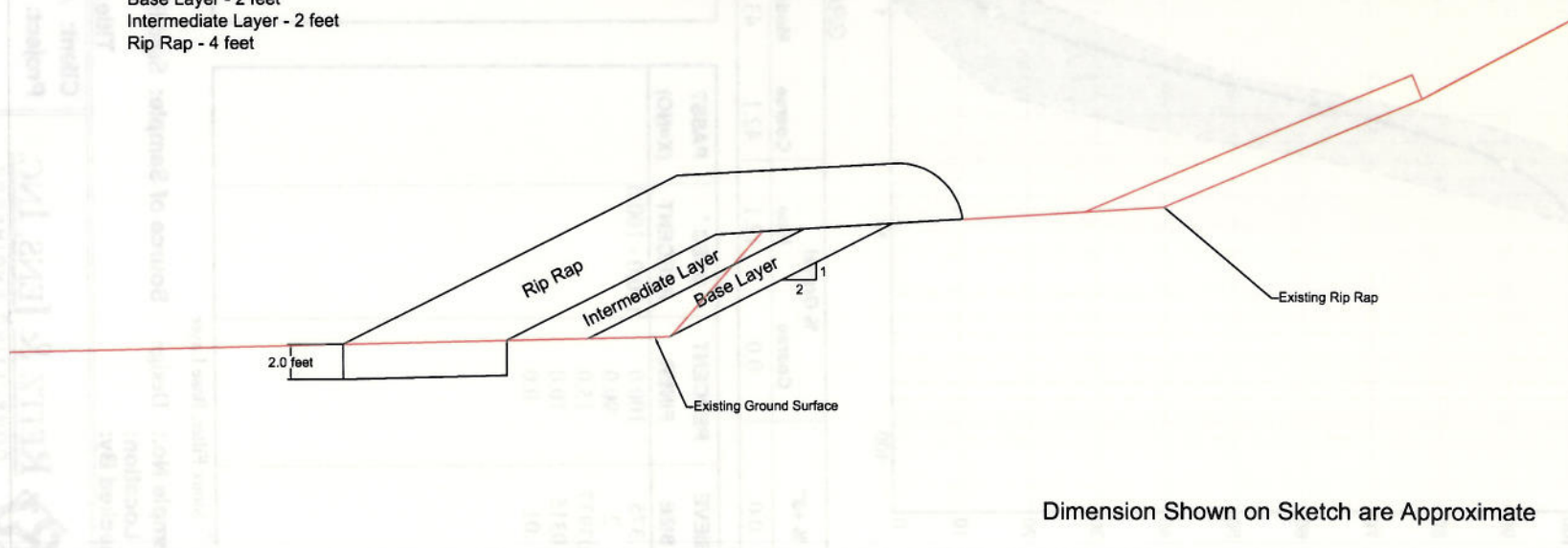


## Sioux Power Station

Inverted Filter  
General Location and Extents  
Cross-section

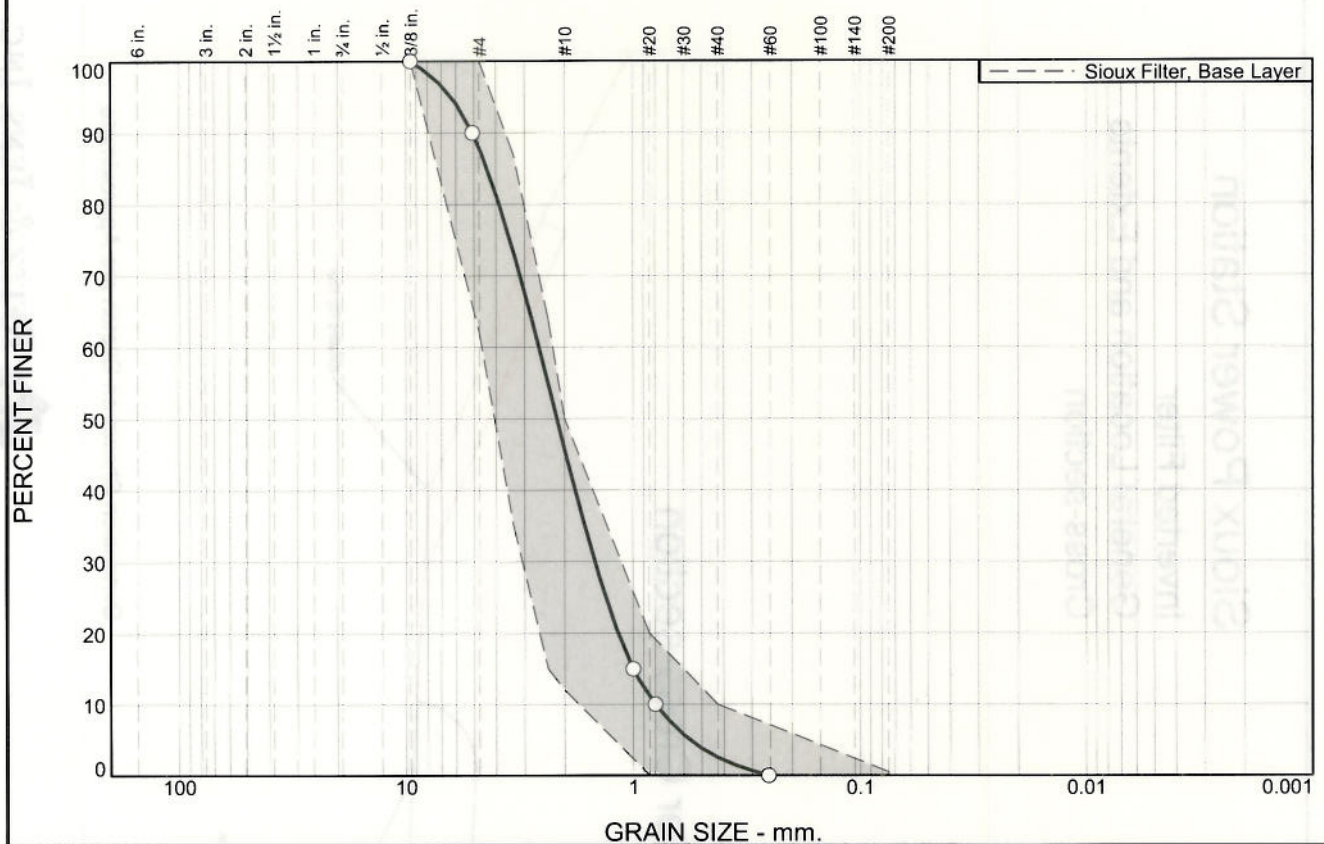
## Inverted Filter Cross-section

Layer Thickness  
Base Layer - 2 feet  
Intermediate Layer - 2 feet  
Rip Rap - 4 feet



Dimension Shown on Sketch are Approximate

# Particle Size Distribution Report - ASTM D422



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	12.1	42.1	43.3	2.5	0.0	0.0

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.375	100.0	100.0 - 100.0	
.2	90.0		
.03937	15.0		
.0315	10.0		
.01	0.0		

## Material Description

Inverted Filter, Base Layer

## Atterberg Limits (ASTM D 4318)

PL= LL= PI=

## Classification

USCS= AASHTO=

## Coefficients

D<sub>85</sub>= 4.3793 D<sub>60</sub>= 2.5959 D<sub>50</sub>= 2.1621  
D<sub>30</sub>= 1.4724 D<sub>15</sub>= 1.0000 D<sub>10</sub>= 0.8001  
C<sub>u</sub>= 3.24 C<sub>c</sub>= 1.04

Date Tested:

Tested By:

Remarks

\* Sioux Filter, Base Layer

Sample No.: Design Source of Sample: Sand Boil Location

Location:

Date Sampled:

Elev./Depth: Lift 1

Checked By:

Title:



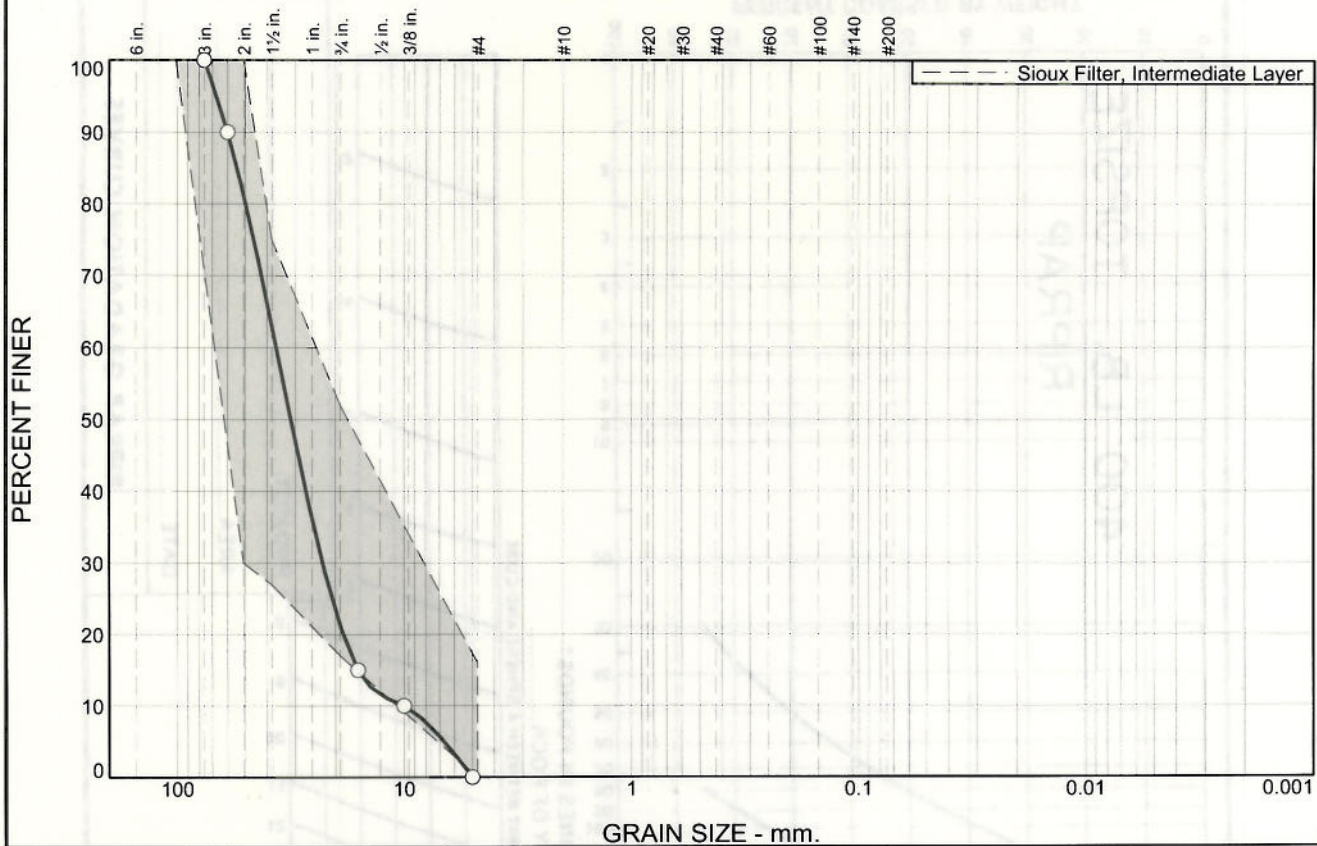
**REITZ & JENS, INC.**  
CONSULTING ENGINEERS

Client: Ameren Missouri  
Project: Bottom Ash Pond Seepage

Project No: 2010012488

Figure C-2

# Particle Size Distribution Report - ASTM D422



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	78.8	21.2	0.0	0.0	0.0	0.0	0.0

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3	100.0		
2.3622	90.0		
.625	15.0		
.3937	10.0		
.19685	0.0		

## Material Description

Inverted Filter, Intermediate Layer

## Atterberg Limits (ASTM D 4318)

PL= LL= PI=

## Classification

USCS= AASHTO=

## Coefficients

D<sub>85</sub>= 54.4038 D<sub>60</sub>= 36.4948 D<sub>50</sub>= 31.4564  
D<sub>30</sub>= 22.7890 D<sub>15</sub>= 15.8750 D<sub>10</sub>= 10.0000  
C<sub>u</sub>= 3.65 C<sub>c</sub>= 1.42

Date Tested: Tested By:

Remarks

\* Sioux Filter, Intermediate Layer

Sample No.: Design Source of Sample: Sand Boil Location

Location:

Date Sampled:

Elev./Depth: Lift 2

Checked By:

Title:



**REITZ & JENS, INC.**  
CONSULTING ENGINEERS

Client: Ameren Missouri

Project: Bottom Ash Pond Seepage

Project No: 2010012488

Figure C-3

# Rip Rap Layer

